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

Third edition
2025-01

Reference number
ISO 11118:2025(en)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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.

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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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.

7.3 Design drawings

Fully dimensioned drawing(s) of the non-refillable cylinder shall be supplied which includes the following as a minimum:

a) material specifications for cylinder shells including, but not limited to R_{eg} and R_{mg} (MPa). In addition, the material specifications for the non-refillable sealing device shall be noted;

b) test pressure (bar);

c) minimum burst pressure (bar);

d) minimum thickness of the cylindrical shell (mm);

e) minimum water capacity (litre) (for cylinders ≤ 2 l, the water capacity may be reported in ml);

f) nominal cylinder outside diameter (mm);

g) dimensions of the cylinder ends (mm);

h) overall length of the cylinder (mm);

i) heat treatment (if any);

j) method of construction;

k) welding/brazing procedure designation (if any);

l) specifications for valve outlet connection or cylinder threaded connection for use (if applicable);

m) cylinder design identification;

n) design standard (i.e. ISO 11118:2025);

o) date and revision identity of drawing;

p) manufacturer's identity;

q) content and position of markings;

r) description of non-refillable sealing device that guarantees non-refillability and, if applicable, piercing force and energy required to pierce membranes.

8 Construction and workmanship

8.1 Construction

8.1.1 Types of construction of cylinder shell

The cylinder shells shall be of seamless, welded, or brazed construction. The minimum wall thickness of the cylindrical shell shall be verified during the production process. The frequency and method used to determine the minimum cylindrical shell wall thickness shall be agreed with the inspector.

8.1.1.1 Seamless construction

8.1.1.1.1 Seamless cylinder shells shall be produced by

a) forging or drop forging from a solid ingot or billet,

b) manufacturing from seamless tube, or

c) pressing from a flat plate (cold deep drawn).

8.1.1.1.2 Welding and brazing are only permitted to attach the non-refillable sealing device.

a) Welding shall be carried out only on cylinders made of weldable materials.

b) Brazing shall be carried out only on cylinders made of materials not degraded by this procedure.

8.1.1.2 Welded construction

8.1.1.2.1 General requirements

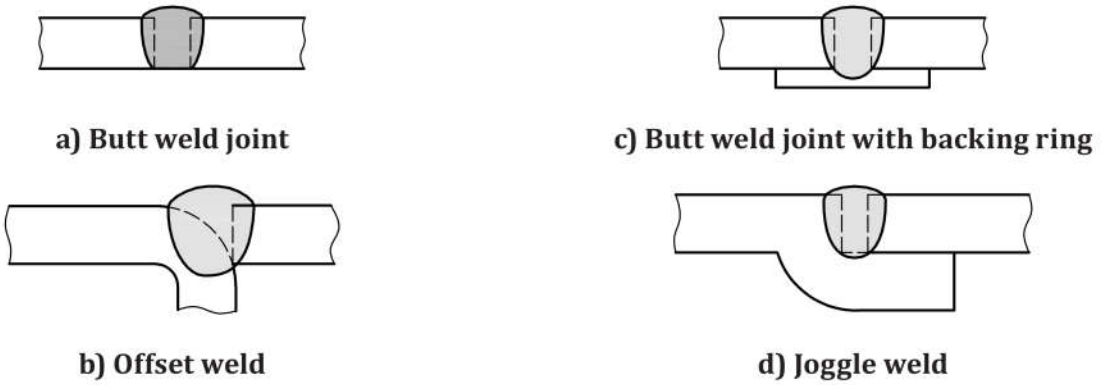
The welding of longitudinal and circumferential seams shall be by a semi-automatic or automatic process.

The longitudinal seam weld, if any, shall be of the butt type weld joint as illustrated in Figure 1 a).

The circumferential seam(s), if any, shall be as illustrated in Figure 1 a), b), c) or d).

Welded joints shall have strength greater than the tensile strength of the finished cylindrical wall.

The welding procedure and operator qualifications shall include, as a minimum, welds representative of those made in production representing the variables in the materials and the process. Requalifying of the procedures and operators shall be required if there is a change in any of the essential variables as specified in 8.1.1.2.2.7.



a) Butt weld joint

c) Butt weld joint with backing ring

b) Offset weld

d) Joggle weld

Figure 1 — Weld joints

8.1.1.2.2 Welding qualifications

8.1.1.2.2.1 General

a) All welding equipment, welding operators and welding procedures may be approved by meeting the requirements of 8.1.1.2.2 to 8.1.1.2.2.9 or those given in ISO 5817 (level B), ISO 9606-1, ISO 10042 (level C), ISO 14732, ISO 15613, ISO 15614-1 and ISO 15614-12, as appropriate.

b) Records of welders and welding operator qualifications and welding procedure qualifications shall be kept on file by the manufacturer.

c) Welding procedure specification approval tests shall be carried out such that the welds shall be representative of those made in production.

d) Welders, welding operators and welding procedures shall pass the approval tests for the specific type of work and procedure specification concerned.

8.1.1.2.2.2 Materials for pressure and non-pressure containing parts

The materials used for qualification shall be the same as those specified in the procedure specification and those used for the production.

8.1.1.2.2.3 Positions of welds

For welder qualification, the position of the part for welding shall be the same as that in the actual manufacturing.

8.1.1.2.2.4 Welding consumables

The weld consumables shall be the same as those specified in the procedure specification, those tested from the welders, and those used for the production.

8.1.1.2.2.5 Retesting

Where a welder or welding operator fails to meet the requirements of this document

a) an immediate retest shall be carried out of two test welds of the type failed, both of which shall meet all the requirements of the standard, or

b) a retest shall be carried out provided there is evidence that the operator has had further training and practice to the design and procedure specification.

8.1.1.2.2.6 Period of validity

A welder and welding operator shall be requalified on the design if the design has not been produced by the welder for a period of six months or more. Records of effectiveness shall be retained by the manufacturer.

8.1.1.2.2.7 Essential variables of the welding process

The welding procedure specification and welder qualification shall be tested and approved when any of the following changes are made, if not already covered:

a) a change to the base materials;

b) a change to the welding material;

c) a change to the weld process;

d) a change to the weld position;

e) a decrease of 30 °C or more in the minimum specified preheating temperature;

f) the omission or addition of a backing ring in single pass welds;

g) a change from multiple pass to single pass per side;

h) a change to the shielding gas or to the composition (if greater than a 15 % change in the mixture);

i) a change from a single arc to multi arc or vice versa.

8.1.1.2.2.8 Welder and weld operator qualification tests

a) For longitudinal welds:

   1) bend test, root of weld;

   2) weld tensile test.

b) For circumferential welds:

   1) macro test;

   2) weld tensile test.

c) For threaded connections to cylinder ends: macro tests, 180° apart.

d) For welded attachments, foot rings, collars, rupture disc, or lugs: macro test.

e) For fillet welds: macro tests, 180° apart.

8.1.1.2.2.9 Acceptance

a) For bend tests:

Upon completion of the test, the test piece (weld metal and base material) shall remain uncracked.

b) For tensile tests:

The tensile strength value obtained, R_{ma}, shall not be less than that guaranteed by the cylinder manufacturer regardless of the fracture location.

c) For macro tests:

The etched specimen shall be prepared to a resolution where visually, examination can occur to determine adequate root penetration into both members as to the established design (e.g. ISO 17639).

8.1.1.3 Brazed construction

Butt weld brazed joints shall not be used.

Three-piece cylinder designs with brazed seams shall not be permitted.

Brazing shall not be used for aluminium or aluminium alloy cylinders.

Brazing materials shall be compatible with the intended gas being placed in the cylinder.

The brazing material shall have a melting point greater than 540 °C.

Brazed seams shall be assembled such as to ensure complete penetration of the brazing material throughout the joint.

Brazed joints shall have strength greater than the tensile strength of the finished cylindrical wall.

Brazing procedures and operators shall be qualified to a written procedure according to, for example, ISO 13585 or EN 13134.

8.1.1.4 Attachments and openings

Attachments to the cylinder including sealing of the neck opening by welding or crimping a pierceable metal membrane shall be by means which are not detrimental to the integrity of the cylinder. Welding or brazing of attachments to the cylinder other than non-refillable sealing device shall be completed prior to the final testing of the cylinder shell (see Clause 11).

There shall be no openings or attachments in the cylindrical shell.

All openings and their reinforcements shall be within an imaginary circle concentric with the centreline axis of the cylinder. The diameter of the circle shall not exceed 80 % of the outside diameter of the cylinder. The plane of the circle shall be perpendicular to the centreline axis of the cylinder (see Figure 2).

If necessary, each opening can be reinforced by a securely attached fitting, boss, pad, collar, or other suitable means.

Material used for welded attachments and fittings shall be of weldable quality and compatible with the cylinder material.

Material used for brazed attachments and fittings shall be of brazable quality and compatible with the cylinder material. The minimum width of the brazed joints shall be at least four times the minimum design shell wall thickness.

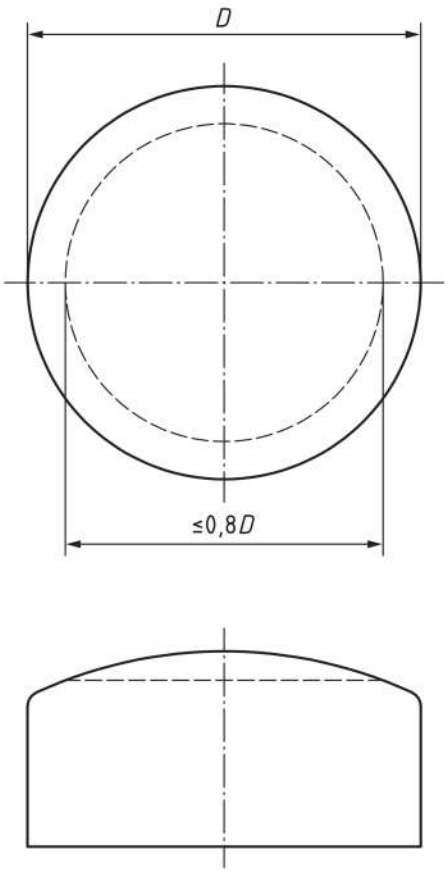


Figure 2 — Openings

8.1.2 Cylinder non-refillability

The cylinder shall be equipped with a device rendering the cylinder non-refillable. This can be accomplished by a valve or a pierceable metal membrane in accordance with Annex A that is permanently attached to the neck opening which, when in place, renders the cylinder non-refillable. Replaceable sealing devices shall not be used.

8.1.3 Pressure relief devices

Where a pressure relief device is an integral part of the cylinder, the manufacturer shall ensure that the pressure relief device has sufficient capacity to prevent rupture of the cylinder. For membranes, see A.4.3.

8.2 Workmanship

The quality of workmanship and construction shall be such as to ensure that cylinders are free from defects, including at least the following:

a) the pressure containing parts shall be of uniform quality and free from surface imperfections which can adversely affect the safe working of the cylinder;

b) before sealing the cylinder or after welding the longitudinal joint, if any, each cylinder shall be clean, dry, and free of any loose particles;

c) after completion of all welded/brazed joints, the weld shall not have concavity, weld under-cutting, or abrupt weld irregularity nor have any cracks or other defects;

d) if filling is part of the cylinder manufacturing process, appropriate regulations can apply to the gas properties and filling conditions.

9 Type approval procedure

9.1 General requirements

A technical specification of each new design of cylinder [or cylinder family as defined in 9.1 f)], including design drawing, design calculations, material details, and heat treatment, shall be submitted by the manufacturer to the inspector. The results of the tests shall be summarized in a report to be kept available by the approval holder and are available for review/inspection when required.

Prototype tests detailed in 9.2 and Annex A shall be carried out on each new design under the supervision of the inspector.

A cylinder shall be considered to be of a new design when at least one of the following applies:

a) it is manufactured in a different manufacturing facility;

b) it is manufactured by a different process (this includes any major process change);

c) it is manufactured from a material of different specification;

d) it is given a different heat treatment, if applicable;

e) either the cylinder profile or the thickness of the starting material have changed relative to the cylinder diameter or calculated minimum thickness of the cylindrical shell, respectively;

f) the overall length of the cylinder has increased by more than 50 % (cylinders with a length/outside diameter ratio less than three shall not be used as reference for any new design with this ratio greater than three);

g) the nominal outside diameter of the cylinder has been increased or decreased by more than 1 % or 5 mm, whichever is greater of the original design diameter;

h) an increase in the test pressure that requires a change in design cylindrical wall thickness;

i) the non-refillable sealing device design has changed.

9.2 Prototype tests

9.2.1 General

A minimum of 50-cylinder shells guaranteed by the manufacturer to be representative of the new design will be tested as described in 9.2.2, 9.2.3, 9.2.4 and 9.2.6. Prior to subjecting the cylinder shells to prototype testing, the cylinder shells are to be subjected to a pressure equal to the test pressure (p_h) and exhibit no leakage or visible distortion. The complete non-refillable cylinders shall be tested as described in 9.2.5 and 9.2.7 (if applicable).

The non-refillable sealing device shall be tested as defined in A.3 or A.4 as applicable.

If the results of the tests conducted in accordance with 9.2.2 to 9.2.7 and Annex A are satisfactory, the inspector shall issue a new design type approval certificate. A typical example is given in Annex B.

9.2.2 Material tests

For carbon steel, a check analysis shall be performed by the cylinder manufacturer on material representative of the cylinders.

Check analysis shall be carried out either on specimens taken during manufacture from the material in the form as supplied by the material manufacturer to the cylinder manufacturer or from finished cylinders. For carbon steels, the maximum permissible deviation from the limits for the cast analyses shall conform to the values specified in ISO 9329-1.

For austenitic stainless steels the cylinder manufacturer shall obtain certificates of the analysis of the cast. If check analysis is required, it shall be carried out either on test specimens taken from material in the form supplied by the producer of the austenitic stainless steel or from finished gas cylinders.

For aluminium alloys, the cylinder manufacturer shall obtain certificates of the analysis of the cast. If check analysis is required, it shall be carried out either on test specimens taken from material in the form supplied by the producer of the aluminium alloys or from finished gas cylinders.

Where use is made of an aluminium alloy containing copper or where use is made of an aluminium alloy containing magnesium and manganese and the magnesium content is greater than 3,5 % or the manganese content lower than 0,5 %, possible intercrystalline corrosion shall be tested for each material specification and heat-treatment method. The test shall be carried out in accordance with ISO 7866:2012, A.1.

9.2.3 Tensile tests

9.2.3.1 Tensile specimens shall be located as shown in Figure 3, except that for cylinders with diameters ≤ 140 mm, transverse tensile specimen for testing the parent material are not required.

9.2.3.2 Tensile specimens shall be prepared and tested in accordance with ISO 6892-1. If due to cylinder size or configuration the specimen size cannot meet the requirements of ISO 6892-1, a smaller sample can be used following the guidelines of ISO 4706.

The cylinder manufacturer shall record the actual tensile strength (R_{ma}), actual yield strength (R_{ea}), and percentage elongation after fracture. For weld tensile test, only the tensile strength (R_{ma}) value shall be determined.

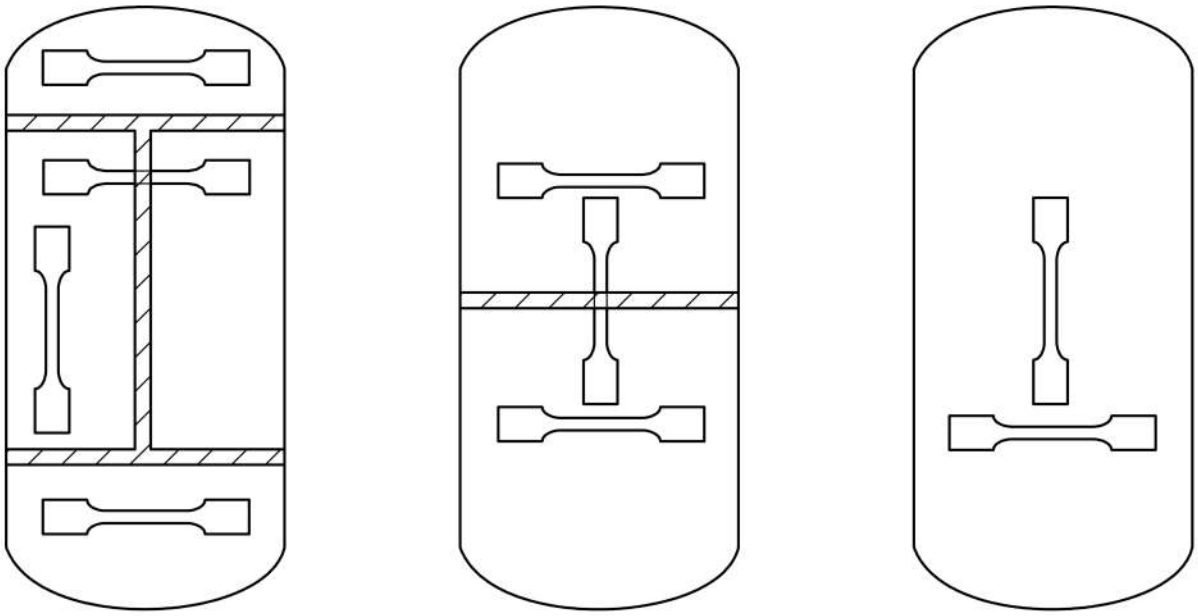
9.2.3.3 All tensile specimens shall exhibit a ductile fracture and mechanical properties for the relevant materials shall be as required in Clause 5 and 7.3. In addition,

a) for heat-treated and non-heat-treated cylinders, the tensile strength (R_{ma}) shall meet the requirements of the design criteria;

b) for heat-treated and non-heat-treated cylinders, the actual yield strength (R_{ea}) shall be $\geq R_{eg}$;

c) for heat-treated and non-heat-treated cylinders, the percentage elongation after fracture shall be recorded. Percentage of elongation determination shall not be required on welded/brazed joint tensile specimens;

d) welded/brazed joint tensile specimens shall not fracture in the welded or brazed joint.



a) Three-piece cylinder b) Two-piece cylinder c) Seamless cylinder

Figure 3 — Location of tensile specimens

9.2.4 Burst tests

9.2.4.1 Burst tests shall be carried out on a minimum of three representative cylinders. If the markings on the cylinder are to be engraved or stamped, all prototypes shall be engraved or stamped prior to burst testing using the marking process used in production. The test can be performed with or without the non-refillable sealing device attached.

Burst testing successfully passing the requirements of 9.2.4.5 fulfils the requirement of this clause.

9.2.4.2 Each cylinder shall be weighed to determine its tare weight. Each cylinder shall then be filled with water to the maximum volume of the cylinder to determine the cylinder water capacity. The cylinder tare weight and water capacity shall be recorded.

9.2.4.3 Tests shall be carried out at room temperature.

9.2.4.4 Non-refillable carbon steel cylinders that have not been heat-treated shall be artificially aged prior to burst testing.

Artificial ageing of the cylinder shall be accomplished by holding it at a temperature of either

a) 100 °C for a minimum of 1 h,

b) 120 °C for a minimum of 15 min, or

c) 150 °C for a minimum of 2,5 min.

After exposure to heat and prior to filling, the cylinder shall be allowed to return to room temperature by air cooling.

Where hydraulic burst testing of the cylinder is not feasible or if the valve or cylinder design prevents a hydraulic fluid from being introduced into the cylinder, a pneumatic burst test can be conducted. When a pneumatic burst test method is used, all safety precautions and considerations shall be taken to ensure the safety of personnel and property.

WARNING — Carrying out a pneumatic burst pressure test is considerably more dangerous than performing a hydraulic burst pressure test. A pneumatic burst pressure test should only be carried out after ensuring that any additional safety requirements (over and above those required for a hydraulic burst pressure test) are in place.

9.2.4.5 The procedure for burst testing cylinders is as follows:

a) For cylinder designs with p_b of < 70 bar, pressurize the cylinder to the test pressure (p_h) at a rate not exceeding 14 bar/min and hold the test pressure for 30 s. There shall be no decrease in the pressure during the 30 s holding period. Once the holding period has passed, increase the pressure in the cylinder at any convenient rate until the cylinder bursts. As an alternative, once the 30 s holding period has ended, the pressure can be decreased below the test pressure before repressurizing until the cylinder bursts. Once the holding period has passed, increase the pressure in the cylinder (at any convenient rate) until the cylinder bursts.

   Measurements shall be taken at discreet intervals during the test (from test start to cylinder burst) of the cylinder pressure and time so as to be able to ascertain the following:

   1) the initial cylinder pressurization rate;

   2) the holding period duration and pressure;

   3) the pressurization rate applied from the end of the holding period to cylinder burst;

   4) the cylinder burst pressure.

   NOTE 1 A time versus cylinder pressure plot can be employed as a means of recording the necessary test parameters.

b) For cylinder designs with p_b of ≥ 70 bar, pressurize the cylinder to the test pressure (p_h) at a rate not exceeding 5 bar/sec and hold the test pressure for 30 s. There shall be no decrease in the pressure during the 30 s holding period. Once the holding period has passed, increase the pressure in the cylinder at any convenient rate until the cylinder bursts. As an alternative, once the 30 s holding period has ended, the pressure may be decreased below the test pressure before repressurizing until the cylinder bursts. Once the holding period has passed, increase the pressure in the cylinder at any convenient rate until the cylinder bursts.

   Measurements shall be taken at discreet intervals during the test (from test start to cylinder burst) of the cylinder pressure and time so as to be able to ascertain the following.

   1) the initial cylinder pressurization rate;

   2) the holding period duration and pressure;

   3) the pressurization rate applied from the end of the holding period to cylinder burst;

   4) the cylinder burst pressure.

NOTE 2 A time versus cylinder pressure plot can be employed as a means of recording the necessary test parameters.

9.2.4.6 The burst test acceptance criteria are the following.

a) The burst pressure shall be equal to or greater than 1,6 times the test pressure of the cylinder.

b) The initiation of the failure shall not be in a weld or braze or in the heat affected zone of a weld or braze.

c) The initiation of the failure shall be in the cylindrical shell of the cylinder, except if the fracture initiation is caused by shear stress in the cylinder ends at the point of an attachment. In all cases, the fracture shall be ductile.

d) The burst cylinder shall remain in one piece under bursting.

e) The burst cylinder shall not exhibit evidence of yield point elongation (see Annex D).

The 1,6 factor may not be aligned with other regulations (i.e. ICAO) for non-refillable cylinders in aircraft service.

9.2.5 Drop tests

9.2.5.1 Drop tests shall be carried out on a minimum of three representative cylinders. The samples for drop testing shall be representative of the final shipping package (e.g. carton, overpack, cylinder cap). The drop tests can be conducted without the final shipping package if this condition would be more severe.

9.2.5.2 The impact surface shall be a concrete block 1 m × 1 m and 0,1 m thick from a single cast composed of cement, sand, and gravel. It shall be protected by a sheet of steel 10 mm thick. The flatness of the protective sheet shall be such that the difference in level of any two points on its surface shall not exceed 2 mm.

9.2.5.3 Cylinders used for liquefied gases shall be filled with water or other inert material (e.g. sand) to the maximum water capacity of the cylinder. Cylinders used for permanent gases shall be filled with water to 40 % of the water capacity of the cylinder. In neither case, shall the cylinder be pressurized for the drop test.

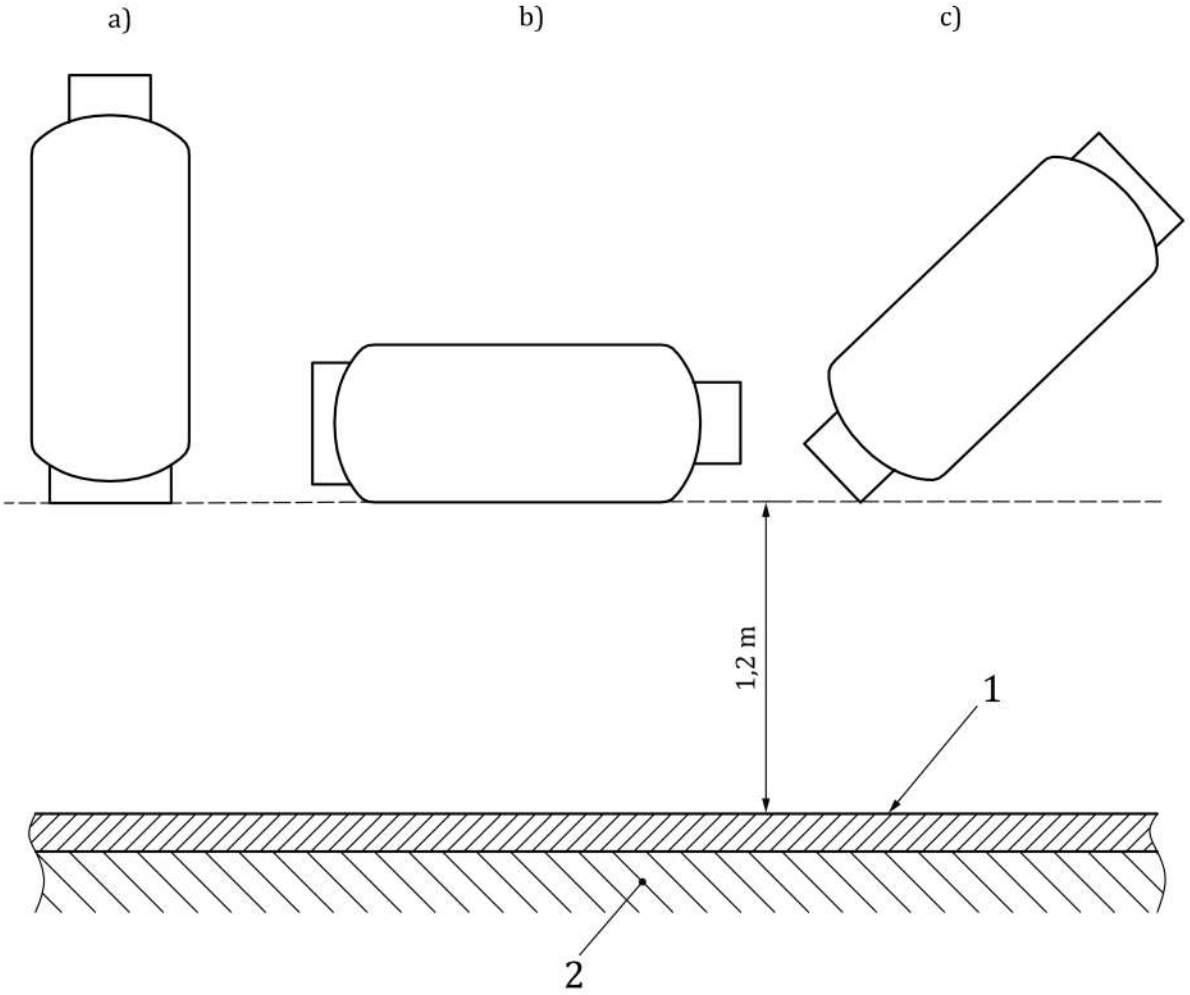
The drop test procedure is the following:

a) one cylinder shall be dropped from a height of 1,2 m with the bottom of the cylinder striking the impact surface as illustrated in Figure 4 a);

b) one cylinder shall be dropped from a height of 1,2 m with the cylinder sidewall striking the impact surface as illustrated in Figure 4 b);

c) one cylinder shall be dropped from a height of 1,2 m with the cylinder cap, collar, guard, or other valve protection device striking the impact surface at a 45° angle as illustrated in Figure 4 c).

9.2.5.4 For cylinders tested as described in 9.2.5.3, the cylinder shall exhibit no leakage at a minimum pressure of 2 bar. The non-refillable sealing device shall remain operational (e.g. capable of being opened and closed, if applicable) and the cylinder shall pass the burst test as described in 9.2.4.



Key

1 impact surface

2 concrete block

Figure 4 — Drop tests

9.2.6 Dimension checks

9.2.6.1 Dimension checks shall be carried out on a minimum of three cylinders. The finished cylinder shall be longitudinally sectioned into sufficient pieces to determine the minimum thickness in the cylindrical shell. Alternatively, ultrasonic measurement or any other equally sensitive method can be used. The minimum thickness shall not be less than the minimum thickness in 7.2 and shall not be less than the minimum thickness specified on the design drawing.

9.2.6.2 The nominal outside diameter (D), length, and ends radii shall be measured and be in accordance with the design drawing (see 7.3).

9.2.7 Valve to cylinder interface test

One sample of each valve and cylinder design shall be subjected to a hydraulic overpressure to prove each design of valve to cylinder interface. The interface shall not fail at < 1,6 times the highest test pressure (p_h) of any cylinder to be used for that design interface.

9.3 Design type approval

Once the results of the prototype tests according to 9.2 (including Annex A) are satisfactory, the inspector shall issue a type approval certificate referring to the design type test report. An example of a certificate of type approval is given in Annex B.

10 Batch tests

10.1 General requirements

A burst test in accordance with 9.2.4 shall be carried out at a frequency of at least one per batch, as specified in Table 4.

The burst tests shall be conducted on randomly selected cylinder shells. All engraved or stamped markings on the cylinder shell or cylinder ends shall be made prior to burst testing. When a cylinder design is assembled from component parts (e.g. a welded or brazed construction), the component parts may be manufactured at a time previous to manufacturing the batch.

Table 4 — Sampling frequency

$p_h V$	Sampling frequency
0 to 50	1/1 000
51 to 300	1/750
301 to 600	1/500
601 to 1 000	1/200

For cylinders with $p_h V$ 0 to 50, the sampling frequency can be reduced to one in 1 500 after 3 000 cylinders. These cylinders shall be:

1) be successfully manufactured; and
2) passed all tests; and
3) have been manufactured consecutively by the same manufacturer using the same manufacturing techniques; and
4) to the same design, size; and
5) same material specifications; and
6) using the same type of welding machines (when applicable), welding procedures (when applicable); and
7) to the same heat treatment conditions (when applicable).

The manufacturing time frame shall not exceed a 12 h time period.

10.2 Failure to meet test requirements

If the cylinder shell fails to meet any of the requirements of 9.2.4.6, the batch shall be rejected. If the cause for the rejection can be determined and the affected cylinders isolated from the batch, the remainder of the batch can be requalified by retesting following the requirements given in 10.1. Any cylinder that fails to meet the requirements of 9.2.4.6 shall be rendered unserviceable (e.g. by crushing).

11 Tests on every cylinder

11.1 Inspection

Each cylinder shall be inspected visually or by any other method giving equal sensitivity for the following:

a) being free of cracks, seams, laminations, or other defects;

b) weld quality.

Inspection of marking conformity shall be at a frequency as noted in Table 4.

11.2 Proof pressure test

WARNING — When pressure testing, appropriate measures shall be taken to ensure safe operation and to contain any energy that can might be released. It should be noted that pneumatic proof pressure tests require more precautions than hydraulic. Any error in carrying out this test is highly likely to lead to a rupture under gas pressure. Therefore, these tests shall be carried out only after ensuring that the safety measures adopted satisfy the safety requirements.

Each non-refillable cylinder, except those used for burst tests, shall be proof pressure tested at a pressure of at least the test pressure (p_h). As an alternative, the cylinder shell shall be pressure tested at a pressure of at least the test pressure (p_h) and the non-refillable cylinder shall be leak tested at time of filling (see 11.3).

The cylinder/cylinder shell shall remain at the proof test pressure long enough, at least 10 s for testing with gaseous media and 30 s for liquid media, to make it possible to validate the integrity of the cylinder and welds.

11.3 Leak testing

Leak testing shall be conducted with the cylinder submerged under water or by any other method giving equal sensitivity of leak detection. Non-refillable sealing devices shall also conform with A.2.3.5 and A.2.2.2.4.

11.4 Rejection criteria

Cylinders shall not exhibit leaks (or pressure reduction), visible distortion, or any other defects during the test.

Cylinders exhibiting any of these defects shall be rejected.

11.5 Repairs

Cylinder weld repairs are permitted. The weld operator and process shall be as defined in Clause 8. Repairs shall be followed by pressure testing as defined in 11.2.

Cylinders that cannot be repaired shall be rendered unserviceable.

12 Markings

12.1 General

The markings shall be durable and waterproof and shall be affixed to the cylinder.

NOTE National regulations can contain additional or overriding requirements.

12.2 Manufacturing and operational markings

12.2.1 Each cylinder shall be marked in accordance with ISO 13769 with the exceptions noted in 12.2.1 to 12.2.6.

NOTE Attention is drawn to national regulations which can contain additional or overriding requirements.

12.2.2 Cylinder sidewalls may be embossed, engraved or stamp marked as long as the minimum cylindrical shell wall thickness is maintained after the marking is applied.

12.2.3 Where cylinders are embossed, engraved, or stamp marked, they shall be burst tested to ensure that the markings do not cause failure and that the markings remain legible.

12.2.4 For cylinders ≤ 40 mm, external diameter markings shall not be less than 1,5 mm in height.

12.2.5 Cylinders used for liquefied gases may use a date code rather than the year and month.

12.2.6 If post manufacturing label application is conducted, there shall be markings in place tracing the cylinder to the manufacturing batch.

12.3 Other markings

In addition to the marking requirements given in 12.2, the cylinder shall also be marked "DO NOT REFILL". This marking shall be a minimum of 5 mm in height, except that for cylinders ≤ 40 mm, external diameter this marking shall not be less than 3 mm in height.

Additional markings can be required by the country of origin or use.

13 Test reports and certificate of conformance

Each batch of non-refillable cylinders, including the non-refillable sealing devices, shall be tested or inspected to state that they conform to this document. The type approval certificate shall be signed by the inspector. An example of a certificate is given in Annex C.

The test reports shall be prepared summarizing all the tests carried out and the results obtained.

These reports shall be signed by the responsible person(s) of the testing organization and shall include drawings, parts, lists, material certificates, etc.

Annex A
(normative)

Non-refillable sealing devices — Specifications and prototype testing

A.1 General

This annex specifies requirements of non-refillable sealing devices (valves, or pierceable metal membranes) to be used with non-refillable cylinders and the method of testing for prototype approval.

A.2 Requirements

A.2.1 General

Non-refillable sealing devices shall operate satisfactorily over the full range of operating temperatures normally from –20 °C to 65 °C.

Non-refillable sealing devices shall be capable of withstanding the mechanical stresses and chemicals they may experience during normal operation.

A.2.2 Requirements for non-refillable valves

A.2.2.1 General

A.2.2.1.1 Valve description

A.2.2.1.1.1 Valves for non-refillable cylinders are typically comprised of the following:

a) a valve body;

b) a valve operating mechanism including the sealing device;

c) connection(s) for use (fill and discharge);

d) a connection system between the valve and cylinder shell.

A.2.2.1.1.2 Also, it can occasionally incorporate the following:

a) a pressure relief device against over pressurization;

b) a dip tube;

c) a screw plug or cap on the outlet connection to ensure leak tightness or protection;

d) an excess flow limiting device.

A.2.2.1.2 Materials

Metallic and non-metallic materials in contact with the gas shall be chemically and/or physically compatible with the gas under all intended operating conditions (as specified in ISO 11114-1 and ISO 11114-2).

For oxygen or other oxidizing gases, the compatibility of the material with these gases and ignition resistance of materials and lubricants should be considered by an appropriate test procedure (e.g. ISO 11114-3).

A.2.2.2 Design and construction

A.2.2.2.1 Valve body

The valve body shall be manufactured by a process that will ensure the reproducibility of the mechanical characteristics necessary to meet the requirements. A threaded valve shall not be able to be removed from the cylinder without destroying the original cylinder thread. This shall be demonstrated by removing a threaded valve from a cylinder and then attempting to install a new threaded valve. It shall not be possible to install a new threaded valve.

The valve body shall be capable of withstanding a hydraulic pressure test in accordance with A.3.2.2.

A.2.2.2.2 Valve operating mechanism

The valve operating mechanism shall be manufactured from materials capable of withstanding the mechanical stresses including possible dynamic loads (for example, pressure shocks or cyclic changes) and the extremes of service temperature to which it may be subjected.

The valve operating mechanism shall

a) be designed in such a way that the cylinders cannot be refilled;

b) not be dependent on the pressure in the cylinder;

c) under normal conditions, operate without difficulty throughout its service life;

d) be designed in such a way that the setting of the operating position of the valve can only be intentionally changed by a positive action;

e) be designed to ensure that lubricants that are not oxygen compatible do not come into contact with oxidizing gases as defined in ISO 10156.

A.2.2.2.3 Leak tightness

External and internal leak tightness shall be achieved over the full range of operating pressures and temperatures.

The leak tightness test is normally carried out with air or nitrogen. Valves designated for use with gases lighter than air shall be subjected to a test using helium or hydrogen. The leak tightness test shall be carried out at:

a) room temperature; and

b) –20 °C; and

c) +65 °C.

A.2.2.2.4 Leakage rate

The internal or external leakage rate shall not exceed 6 cm^3/h at normal temperature and pressure (20 °C and 1 013 mbar).

The specified rate can be reduced by agreement and subject to special applications, for example, for valves for highly toxic or high purity gas service, a lower leakage rate may be specified.

EXAMPLE The leakage of 6 cm^3/h is approximately 4 bubbles of 3,5 mm diameter per minute.

A.2.3 Requirements for pierceable metal sealing membranes

A.2.3.1 General

Pierceable metal sealing membranes shall retain their sealing properties and piercing force requirements throughout the full range of operating temperatures normally from −20 °C to 65 °C. Pierceable metal sealing membranes shall be capable of withstanding the mechanical stresses and contents they can experience during normal operation.

A.2.3.2 Materials

The membrane material in contact with the gas shall be chemically and/or physically compatible with the gas according to ISO 11114-1 and ISO 11114-2 under all intended operating conditions.

For oxygen or other oxidizing gases, the compatibility of the membrane material with these gases and ignition resistance of materials and lubricants shall be verified in accordance with an appropriate test procedure, such as ISO 11114-3.

A.2.3.3 Design and construction

The membrane shall be designed so that it can be used only once. The membrane can incorporate a separate seal and/or a central pierceable area. It shall be constructed so that the force required to open the membrane shall meet the specified limits for piercing force and energy required to pierce. Where the membrane is attached to the neck opening by welding, the material shall be of weldable quality, shall be conducted using compatible welding consumables (if applicable), and shall be compatible with the cylinder material.

A.2.3.4 Leak tightness

Internal leak tightness shall be achieved over the full range of service pressures and temperatures.

The leak tightness test is normally carried out by differential weighing of the filled cylinder after a suitable storage period or by an appropriate gas leak detection systems with a sensitivity to meet the requirements of A.2.3.5.

A.2.3.5 Leakage rate

The leakage rate for the membrane and the associated welded areas shall not exceed 0,355 2 cm^3/h at test temperature (see A.4.4).

The specified rate may be amended by agreement and subject to special applications, for example, for membranes for highly toxic or high purity gas service, a lower leakage rate may be specified.

A.3 Prototype tests of permanently attached non-refillable valves

A.3.1 General

A minimum of eight-cylinder (eleven-cylinder valves if the application is oxygen or oxidizing gases) valves guaranteed by the manufacturer to be representative of the design shall be made available for prototype testing.

Before valves are introduced into service, they shall be submitted for prototype testing which shall be carried out separately from the prototype testing of the cylinder shell. The manufacturer shall make available to the inspector a set of drawings consisting of the general arrangement, parts list, and material specifications. Any type variant within the given family shall be clearly identified.

a) Description of valve and method of operation.

b) Information on the field of application of the valve (e.g. gases and gas mixtures, pressures, use with or without valve protection device). It shall be clearly indicated which gases and gas mixtures can be used with each type variant.

A.3.2 Test valves

A.3.2.1 Schedule of tests

The inspector shall select eight-valves (eleven-cylinder valves if the application is oxygen or oxidizing gases) for testing.

a) One sample (no. 1) for the hydraulic pressure test (see A.3.2.2).

b) Five samples (no. 2 to no. 6) for the leak tightness test (see A.3.2.3).

c) One sample (no. 7) for the non-refillability test (see A.3.2.4).

d) One sample (no. 8) for any additional test which may be required.

e) For oxygen service, three additional samples (no. 9 to no. 11) shall be subjected to the oxygen pressure surge valve test (see A.3.2.5).

A.3.2.2 Hydraulic pressure test

For safety reasons, this test shall be carried out prior to all other tests. The hydraulic pressure test shall be carried out with the following:

a) the valve seat in open position;

b) the valve outlet connection sealed;

c) any safety relief devices (where fitted) removed and the opening sealed;

d) the test medium is water or any other suitable fluid;

e) the hydraulic test pressure minimum is 1,6 times the test pressure of the cylinder shell;

f) the test temperature is the room temperature;

g) the pressure holding time is 2 min minimum.

The pressure shall be raised continuously and gradually. The prototype valve shall withstand the test pressure without permanent deformation or rupture.

A.3.2.3 Leak tightness test

Five samples shall be tested. Both internal (across the seat) and external (using the adaptor, if any) leak tightness shall be tested at 0,5 bar and at p_{vt} Both internal (across the seat) and external (using the adaptor, if any) leak tightness shall be tested at 0,5 bar and at p_{vt} at -20 °C, room temperature (typically between 15 °C and 30 °C) and 65 °C. The leak rate shall not exceed the requirements of A.2.2.2.4.

a) The value for p_{vt} shall be

   1) for compressed gases, $p_{vt} = 1{,}2 \times p_{w;}$

   2) for liquefied gases, p_{vt} is at least equal to the minimum test pressure of the cylinder quoted in the relevant transportation regulation for that gas or gas group taking account of the actual filling ratio to be used.

b) The valve shall be tested in the flow direction, in the two following conditions:

   1) the valve closed, and

2) the valve open (by an appropriate device, if any) the outlet being plugged.

A.3.2.4 Testing for non-refillability

One sample shall be tested to ensure the valve will resist a positive pressure in the reverse flow direction. The test media shall be air for valves used for compressed gases and water may be used for liquefied gases.

a) For non-return valve types, either

1) attach a suitable container of the same water capacity as the cylinder intended to be used to the valve outlet. The valve stem shall be at atmospheric pressure for these tests. Pressurize the container to a positive pressure of 10 % of p_{vt}, but not less than two bar. Ensure that the valve is open. After 1 h, check the pressure in the container. The fall in pressure of the container shall not exceed 5 % of the original pressure, or

2) attach the valve stem to a suitable empty container of the same water capacity as the cylinder intended to be used. Apply a continuous positive pressure of 10 % of p_{vt}, but not less than 2 bar to the valve outlet. Ensure that the valve is open. After 1 h, check the pressure in the container. The pressure in the container shall not exceed 5 % of the applied pressure.

b) For valves of the single use operating mechanism type.

1) By visual examination, it shall be established that it is not possible to reassemble the mechanism for the purpose of refilling.

A.3.2.5 Oxygen pressure surge valve test

Three samples shall be tested at p_{vt} in accordance with ISO 10297.

The value for p_{vt} shall be

a) for compressed gases, $p_{vt} = 1{,}2 \times p_w$, and

b) for liquefied gases, p_{vt} is at least equal to the minimum test pressure of the cylinder quoted in the relevant transportation regulation for that gas or gas group taking account of the actual filling ratio to be used.

A.4 Prototype tests of pierceable metal sealing membranes

A.4.1 General

The test specified in this clause shall be carried out on completed non-refillable cylinder. The manufacturer shall make available to the inspector the following:

a) a set of drawings consisting of the general arrangement, parts list, and material specifications;

b) which gases and gas mixtures can be used with each pierceable metal sealing membrane;

c) certificates of material.

A.4.2 Schedule of tests

A minimum of fifty non-refillable cylinders guaranteed by the manufacturer to be representative of the new design shall be made available for prototype testing. Out of these cylinders, the following samples shall be taken as a minimum:

a) two samples for the burst pressure test and interface test (see A.4.3);

b) five samples for the leak tightness test (see A.4.4);

c) one sample for any additional test which can be required.

A.4.3 Membrane/cylinder interface test

After filling and sealing the cylinder, the gas shall be released by drilling a suitable hole in the cylinder base (furthest from the membrane). The cylinder shall be hydraulically pressurized through this hole.

The membrane shall pass when it does not become detached from the cylinder and

a) where the membrane acts as a pressure relief device, it releases the contents at a pressure in excess of the test pressure without the cylinder rupturing, or

b) where the membrane acts simply as sealing device, the cylinder ruptures at a pressure exceeding 1,6 times the test pressure.

A.4.4 Leak tightness test

The sample shall consist of five filled and sealed cylinders. The leak tightness test shall be carried out by heating the sample to a temperature sufficient to achieve a pressure of at least p_{vt} in the cylinder. The leak rate shall not exceed the requirements of A.2.3.5.

Annex B
(informative)

Type approval certificate

This annex provides an example of a suitable form of a type approval certificate. Other formats are also acceptable.

TYPE APPROVAL CERTIFICATE

Issued by: _____

(Inspector)

Applicable regulation or ISO-Standard: **ISO 11118**

Date: _____

Approval number: _____

Type of cylinder shell: _____

Drawing number(s) _____

_____

P_h	_____	bar	D_{min}	_____	mm
D_{max}	_____	mm	a	_____	mm
L_{min}	_____	mm	L_{max}	_____	mm
V_{min}	_____	L	V_{max}	_____	L

Material specifications: R_{eg} _____ MPa R_{mg}_____ MPa

Heat treatment (if any): _____

Manufacturer or agent: _____

(Manufacturer or agent name)

_____

(Address)

All the information can be obtained from:

_____

(Name of approval body)

_____

(Address of approval body)

Type of non-refillable sealing device

Drawing number _____

Manufacturer _____

Type of non-refillable cylinder

Drawing number _____

Manufacturer _____

I hereby certify that the non-refillable cylinders represented by this certificate comply with the design requirements of ISO 11118.

Signature of inspector: _____

Date: _____

Annex C
(informative)

Certificate of conformance

This annex provides an example of a suitable form of a certificate of conformance. Other formats are also acceptable.

CERTIFICATE OF Conformance

Issued by: _____

(Inspector)

Applicable regulation or ISO-Standard: ISO 11118

Date: _____

Approval number: _____

Type of cylinder shell: _____

Drawing number(s) _____

_____

Drawing number	Manufacturer	Batch number	Burst pressure (bar)	Fracture location	Ductile fracture (Y or N)

Batch number	C	Mn	P	S	Al	Si

NOTE The chemical analyses symbols can be modified depending on the material being used (e.g. carbon steel, aluminium, stainless steel, etc.).

All the information can be obtained from:

_____

(Name of approval body)

_____

(Address of approval body)

Type of non-refillable sealing device

Drawing number _____

Manufacturer _____

Type of non-refillable cylinder

Drawing number _____

Manufacturer _____

I hereby certify that the non-refillable cylinders represented by this certificate comply with the design requirements of ISO 11118.

Signature of inspector: _____

Date: _____

Annex D
(informative)

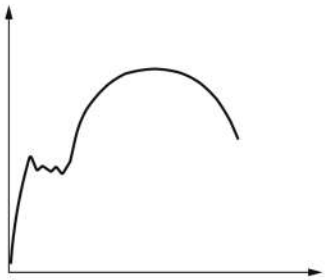
Yield point elongation (YPE)

The information in this annex is given to assist the user of this document in understanding yield point elongation (YPE).

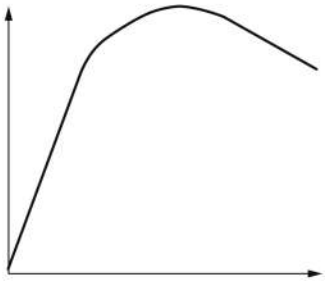
Yield point elongation is defined as the extension associated with discontinuous yield which occurs at approximately constant load following the onset of plastic flow. It is associated with the propagation of Luder lines or stretcher strain visible on the material surface. Yield point elongation (YPE) in cold rolled steel is usually associated with not using enough extension (typically less than 1,0 %) in the temper-mill following the anneal operation. Continuous annealed steel can be more susceptible to YPE versus batch annealed materials. To eliminate YPE, cold rolled steel should be temper-rolled (typically greater than 1,5 %) after annealing. Temper-rolling is typically the last step in the manufacturing process to produce cold rolled steel.

In materials that exhibit a yield point, the yield point elongation (YPE) is the difference between the elongation of the specimen at the start and at the finish of discontinuous yielding (the area in which an increase in strain occurs without an increase in stress).

Yield point elongation (YPE) can be determined by review of the stress-strain curve in the material. Below are examples of stress-strain curves with and without yield point elongation (YPE).



a) Stress-strain curve with YPE



b) Normal stress-strain curve

Figure D.1 — Stress curves

Yield point elongation (YPE) can impact the strength of a non-annealed completed cylinder and cause the unexpected rupture of the cylinder at a pressure less than the minimum setting of the pressure relief device. In order to detect yield point elongation (YPE), it is necessary to artificially age the non-annealed cylinder prior to conducting the burst test as defined in 9.2.4.4.

After artificially aging and burst testing a non-annealed cylinder, yield point elongation (YPE) can be visually present in a highly stressed area. The following photographs are of material demonstrating yield point elongation (YPE).

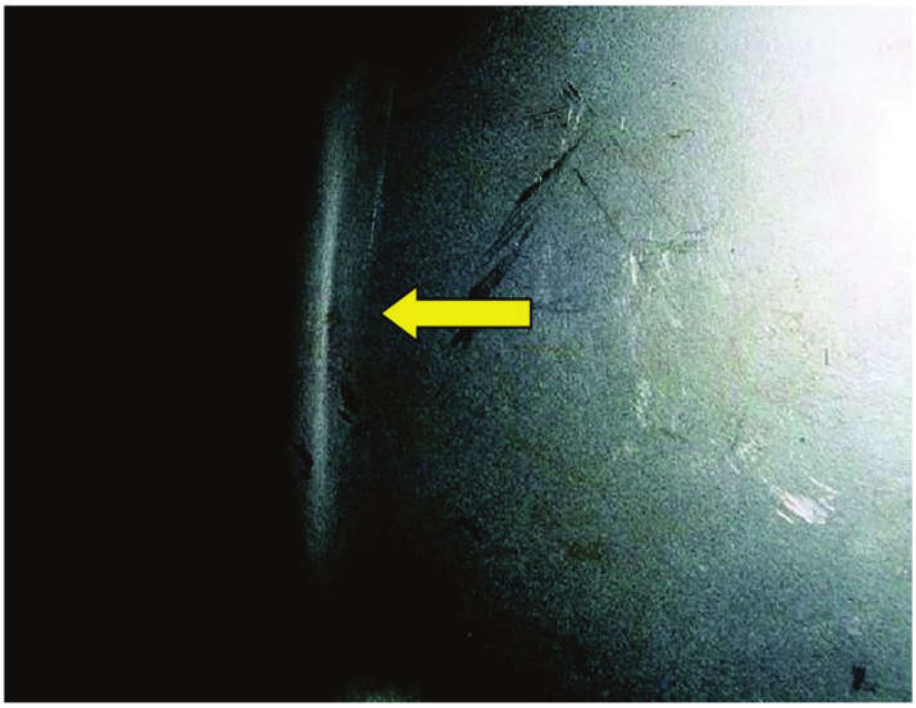


Figure D.2 — Typical YPE strain lines in carbon steel

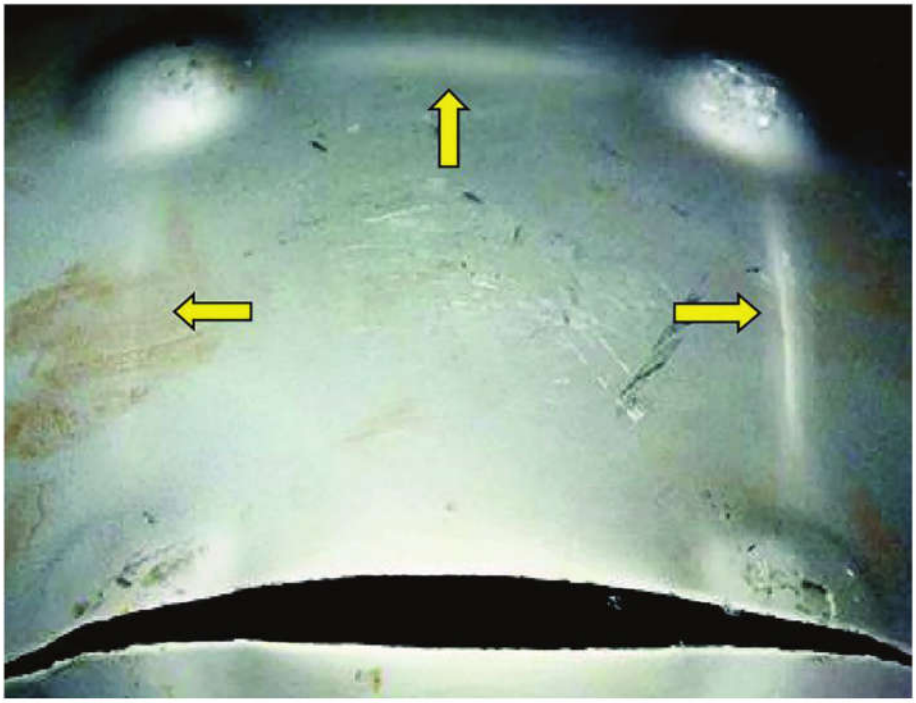


Figure D.3 — Example of YPE strain lines and YPE fracture

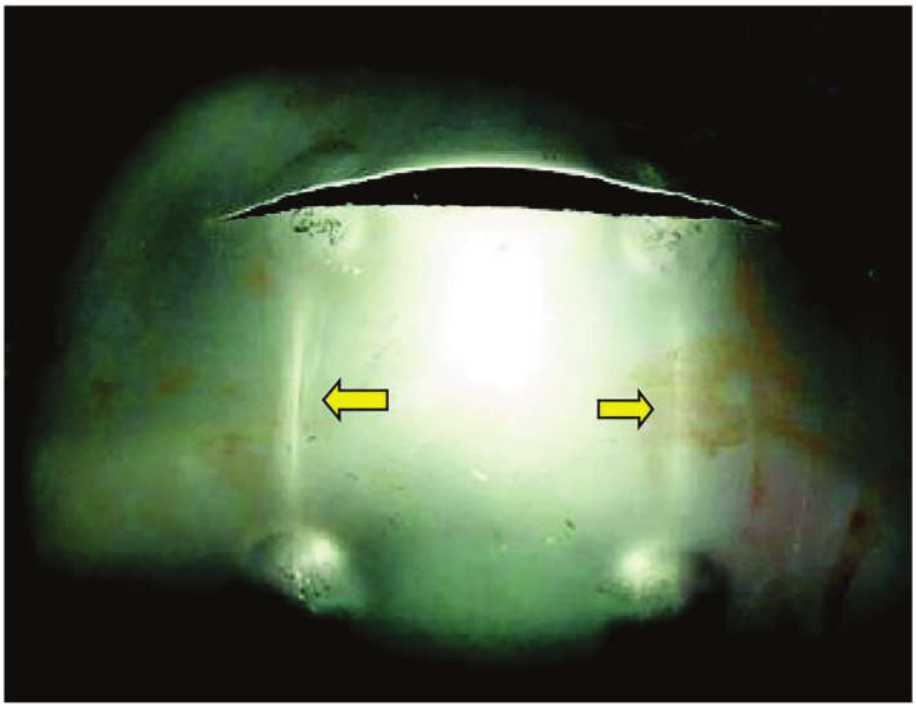


Figure D.4 — Example of YPE strain lines and YPE fracture

Bibliography

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

[2] ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

[3] ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*

[4] ISO 11114-3, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 3: Autogenous ignition test for non-metallic materials in oxygen atmosphere*

[5] ISO 13585, *Brazing — Qualification testing of brazers and brazing operators*

[6] ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

[7] ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

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

[9] EN 13134, *Brazing — Procedure approval*

[10] UN Model Regulations, Recommendations on the Transport of Dangerous Goods — Model Regulations

ICS 23.020.35
Price based on 34 pages