
**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

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 3.

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.

International Standard ISO 11118 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Gas cylinder design*.

Annex A forms a normative part of this International Standard.

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Introduction

The purpose of this International Standard is to provide a specification for the design, manufacture, inspection and testing of non-refillable metallic gas cylinders for worldwide usage. The objective is to balance design and economic efficiency against international acceptance and universal utility.

This International Standard aims to eliminate the concern about climate, duplicate inspections and restrictions currently existent because of lack of definitive International Standards. This International Standard should not be considered as reflecting on the suitability of the practice of any nation or region.

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

1 Scope

This International Standard specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of non-refillable metallic gas cylinders of welded, brazed or seamless construction for compressed, liquefied and dissolved gases exposed to extreme worldwide ambient temperatures.

NOTE The specific gases permitted in cylinders constructed to this International Standard may be limited by ISO, national requirements or international requirements.

This International Standard is applicable to cylinders where:

- a) the maximum permissible operating pressure does not exceed 250 bar (i.e. $p_{ms} \leq 250$ bar);
- b) the product of the maximum permissible operating pressure and the water capacity does not exceed 1 000 bar.litres (i.e. $p_{ms} \cdot V \leq 1\,000$ bar.l);
- c) where the maximum permissible operating pressure exceeds 35 bar, the water capacity does not exceed 5 l (i.e. for $p_{ms} > 35$ bar, then $V \leq 5$ l).

This International Standard is not applicable to cylinders exceeding these pressure and volume limits, for which reference may be made to refillable cylinder standards.

This International Standard is also not applicable to cartridges/aerosol dispensers¹⁾ and spherical containers.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*.

ISO 3574:1986, *Cold reduced carbon steel sheet of commercial and drawing qualities*.

¹⁾ Cartridges are non-refillable containers which do not contain an integral dispensing device, have a maximum water capacity of 1 l and have a limited maximum permissible operating pressure (as defined by the country of use). Aerosol dispensers are non-refillable thin-walled containers which do contain an integral dispensing device, have a maximum water capacity of 1 l and have a limited maximum permissible operating pressure (as defined by the country of use).

ISO 3807²⁾, *Dissolved acetylene cylinders — Basic requirements.*

ISO 4705:1983, *Refillable seamless steel gas cylinders.*

ISO 4706, *Refillable welded steel gas cylinders.*

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

ISO 7866:1999, *Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing.*

ISO 9328-5, *Steel plates and strips for pressure purposes — Technical delivery conditions — Part 5: Austenitic steels.*

ISO 9809-1:1999, *Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1100 MPa.*

ISO 9809-2:1999, *Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 2: Quenched and tempered steel cylinders with tensile strength greater than or equal to 1100 MPa.*

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

3 Terms and definitions

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

3.1 batch

quantity of completed and pressure-tested cylinders of the same design, prototype design, water capacity, material, heat treatment (if any) and manufacturing process made successively during one production shift of up to 12 h

3.2 cylindrical shell

portion of the cylinder, excluding the heads (ends), which is parallel to the centreline axis of the cylinder

3.3 heads (ends)

portions of the cylinder which are not parallel to the centreline axis of the cylinder

3.4 material certificate

document, issued by the material manufacturer, which states 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 maximum permissible operating pressure

highest pressure permitted to be developed during service

²⁾ To be replaced by ISO 3807-1 and ISO 3807-2.

3.7**test pressure**

required pressure applied during the pressure test (see annex A)

3.8**working pressure**

settled pressure of permanent gas at a uniform temperature of 15 °C (288 K) (see annex A)

3.9**maximum operating temperature**

maximum ambient temperature to which the cylinder contents can be exposed in the country of use (see annex A)

3.10**minimum operating temperature**

minimum ambient temperature to which the cylinder contents can be exposed in the country of use (see annex A)

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 (variable)
p_h	Hydraulic test pressure, in bar ³⁾ above atmospheric pressure
p_{ms}	Maximum permissible operating pressure, in bar ³⁾ above atmospheric pressure
p_w	Working pressure, in bar ³⁾ above atmospheric pressure
R_e	Minimum guaranteed value of yield stress, in megapascals, for the finished cylinder
R_g	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**

5.1.1 Non-refillable gas cylinders shall be made of carbon or low alloy steels, austenitic stainless steel, aluminium or aluminium alloys.

The materials used are specified by type (see 5.2) and chemical composition (see 5.3).

Materials shall not contain seams, cracks, laminations or other injurious defects.

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/supplier of the material. The certificate shall be issued by the manufacturer of the material and shall confirm compliance with the material specification.

³⁾ 1 bar = 10⁵ Pa = 0,1 MPa.

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

5.1.5 All materials used in the construction of the pressure-containing parts of the cylinder shall be identified by the cast number/code.

5.1.6 The steels shall be suitable for use at the minimum operating temperature or $-20\text{ }^{\circ}\text{C}$, whichever is the lower.

5.1.7 The material used for cylinder manufacture shall be compatible with the intended gas service (e.g. corrosive gases, embrittling gases), as specified in ISO 11114-1.

5.1.8 Cylinders for service with dissolved acetylene shall incorporate an appropriate porous mass. The completed cylinder containing the porous mass shall meet the requirements of ISO 3807.

5.2 Type

5.2.1 Carbon and low-alloy steels

5.2.1.1 The steel used for the fabrication of gas cylinders shall be made in an electric furnace or by the basic oxygen process, shall have non-ageing properties and shall be killed.

5.2.1.2 Carbon steel for cold deep drawn welded or brazed cylinders shall be in accordance with Table 1 of ISO 3574:1986, having non-ageing properties, drawing quality, processed free of stretcher strains and shall have an aluminium content in excess of 0,01 %.

The chemical composition shall meet the requirements of 5.3.1.1.

5.2.1.3 Carbon steel for other welded cylinders 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 cylinders 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 comply with either ISO 4705, ISO 4706, ISO 9809-1 or ISO 9809-2.

5.2.2 Aluminium and aluminium alloys

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

5.2.2.2 Aluminium and aluminium alloys shall have a chemical composition which meets the requirements of 5.3.2.

5.2.2.3 Aluminium and aluminium alloys for seamless cylinders shall meet the requirements of ISO 7866.

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 shall be in accordance with ISO 9328-5.

5.2.3.4 The chemical composition shall meet the requirements of 5.3.3.

NOTE 1 There is a risk of sensitization to intergranular corrosion resulting from hot working/welding of certain stainless steels. In such cases consideration should be given to carrying out an intergranular corrosion tests, for example as specified in ISO 3651-2.

NOTE 2 Some grades of stainless steels may 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 in accordance with Table 1 of ISO 3574:1986, having non-ageing properties, drawing quality for cold deep drawn welded or brazed cylinders shall have the following chemical composition limits, in (m/m):

Carbon	≤ 0,12
Manganese	≤ 0,5
Phosphorus	≤ 0,025
Sulphur	≤ 0,025

5.3.1.2 Carbon steel for welded cylinders other than cold deep drawn shall have the following chemical composition limits, in (m/m):

Carbon	≤ 0,25
Manganese	≤ 0,5
Phosphorus	≤ 0,025
Sulphur	≤ 0,025

5.3.1.3 Carbon steel for cylinders made of seamless steel tubing with integrally formed ends, hot drawn and finished shall have the following chemical composition limits, in (m/m):

Carbon	≤ 0,55
Manganese	≤ 1,2
Phosphorus	≤ 0,025
Sulphur	≤ 0,025

5.3.1.4 Low alloy steels shall comply with 5.2.1.5.

5.3.2 Aluminium and aluminium alloys

Aluminium and aluminium alloys may be used to produce gas cylinders provided that they meet all requirements of this International Standard and have maximum lead and bismuth contents not exceeding 0,003 %.

NOTE A list of registered alloys is maintained by the Aluminum Association Inc.⁴⁾ entitled *Registration Record of International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys*.

5.3.3 Austenitic stainless steels

Austenitic stainless steel shall meet the requirements of ISO 9328-5.

⁴⁾ Aluminum Association Inc., 900, 19th Street N.W., Washington DC, 20006-2168, U.S.A.

6 Inspection and testing

Evaluation of conformity is required to be performed in accordance with the relevant regulations of the country(ies) where the cylinders are to be used.

In order to ensure that the cylinders are in compliance with this International Standard they shall be subject to inspection and testing in accordance with clauses 9, 10 and 11 by an authorized inspection authority (hereafter referred to as 'the inspector') recognized in the countries of use. The inspector shall be competent for inspection of cylinders.

7 Design

7.1 General

7.1.1 The calculation of the cylindrical wall thickness of the pressure-containing parts shall be related to the yield stress (R_e).

7.1.2 The relationship between the working pressure, maximum permissible operating pressure and the test pressure shall be in accordance with annex A.

7.1.3 The design of the heads shall be such that the pressure-containing parts when subjected to the test pressure (p_h) shall not show any permanent visible deformation.

7.2 Calculation of dimensions of pressure-containing parts

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

a) The minimum thickness of the cylindrical shell shall be not less than that necessary for the minimum burst pressure to be greater than two times the hydraulic 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 be not less than that calculated by the Lamé-von Mises formula, as follows:

$$a = \frac{D}{2} \left[1 - \sqrt{\frac{10FR_e - \sqrt{3}p_h}{10FR_e}} \right]$$

where $F = 1$.

c) The minimum thickness of the cylindrical shell shall be not less than that calculated using one of the following formulae:

$$\text{for steel: } a = \frac{D}{650} + 0,5 ;$$

$$\text{for aluminium and aluminium alloys: } a = \frac{D}{300} + 0,5 .$$

7.3 Design drawing

A fully dimensioned drawing of the cylinder shall be supplied which includes as a minimum:

- material specifications including R_e and R_g in megapascals;
- test pressure in bar;

- c) minimum burst pressure in bar;
- d) minimum thickness of the cylindrical shell in millimetres;
- e) minimum water capacity in litres;
- f) nominal cylinder outside diameter in millimetres;
- g) dimensions of heads in millimetres;
- h) overall length of the cylinder in millimetres;
- i) heat treatment (if any);
- j) method of construction;
- k) welding/brazing procedure designation;
- l) valve connection specification;
- m) cylinder design identification and approval number;
- n) design standard (i.e. ISO 11118);
- o) date and revision identity of drawing;
- p) manufacturer's identity;
- q) content and position of markings.

8 Construction and workmanship

8.1 Construction

8.1.1 General

8.1.1.1 Types of construction

The cylinder shall be of seamless, welded or brazed construction.

8.1.1.2 Seamless construction

Seamless cylinders shall be produced by:

- a) forging or drop forging from a solid ingot or billet or
- b) manufacturing from seamless tube or
- c) pressing from a flat plate.

Welding and brazing shall be carried out for no other purpose than the provision of attachments and openings (see 8.1.2) and shall comply with the requirements of 9.2.6. Furthermore:

- welding shall be carried out only on cylinders made of weldable materials;
- brazing shall be carried out only on cylinders made of materials not degraded by this procedure.

8.1.1.3 Welded construction

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 lap- or butt-welded. The weld joint shall be as illustrated in Figure 1 a), b), c), d) or e).

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

Welding procedures and operators shall be qualified to a written procedure agreed between the parties. The qualification 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 these essential variables. Records of the qualification shall be kept on file by the manufacturer.

NOTE Where a national standard is recognized in the country of use it would be expected that the qualification would be to that standard.

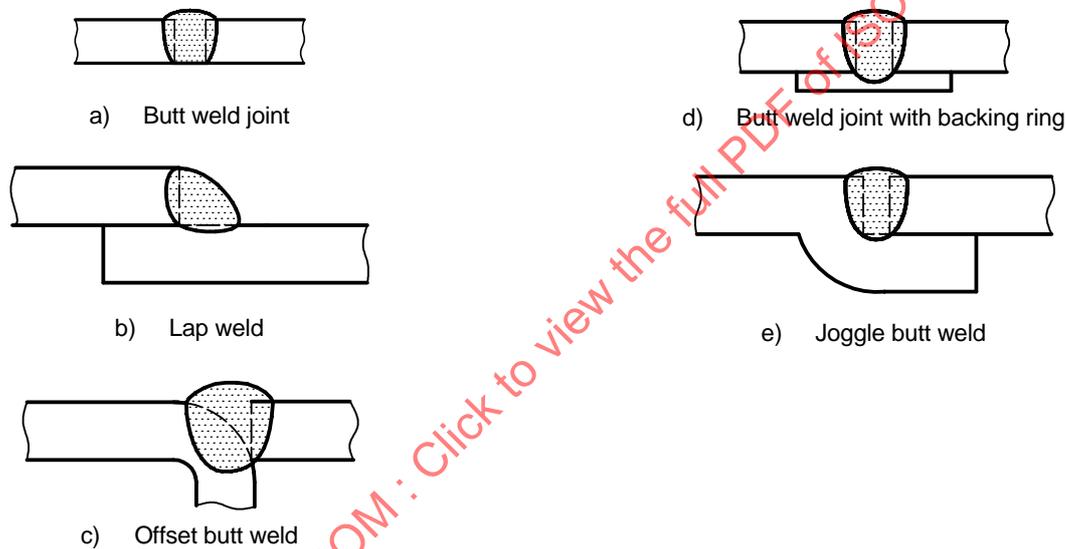


Figure 1 — Weld joints

8.1.1.4 Brazed construction

Brazing shall not be used for aluminium cylinders.

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 a strength greater than the tensile strength of the finished cylindrical wall.

Brazing procedures and operators shall be qualified to a written procedure agreed between the parties. The qualification shall include, as a minimum, brazed joints 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 these essential variables. Records of the qualification shall be kept on file by the manufacturer.

NOTE Where a national standard is recognized in the country of use it would be expected that the qualification would be to that standard.

8.1.2 Attachments and openings

Attachments to the cylinder, including sealing of the neck opening by welding a pierceable steel cap, shall be by means which are not detrimental to the integrity of the cylinder. Welding or brazing of attachments to the cylinder shall be completed prior to the final testing of the cylinder (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).

Where necessary each opening shall 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 length of fit shall be at least 4 times the minimum thickness of the cylindrical shell.

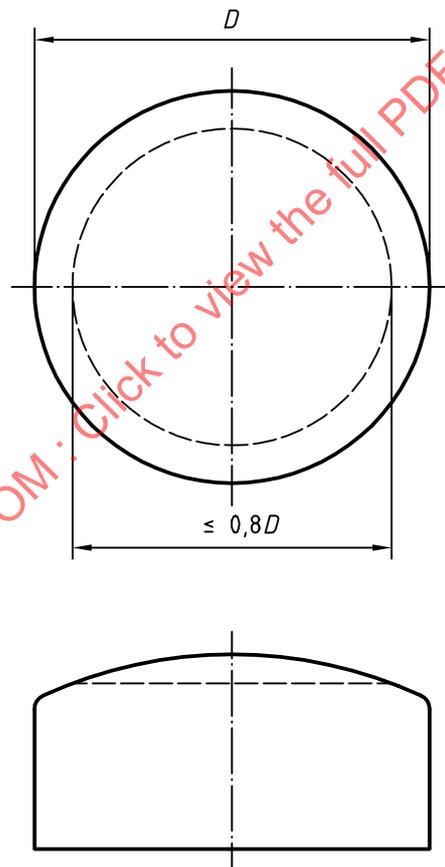


Figure 2 — Openings

8.1.3 Valves

The cylinder valve shall incorporate a shut-off device which prevents the unintentional venting of the product.

The requirement to use a non-refillable feature on the shut-off device is governed by the national authority of the country of use.

8.1.4 Pressure-relief devices

The requirement to use pressure-relief devices is governed by the national authority of the country of use.

Where a pressure-relief device is an integral part of the cylinder, the manufacturer of the cylinder shall size the pressure relief device to have sufficient relieving capacity to prevent the rupture of the cylinder during a fire test conducted according to the requirements of the national authority of the country of use.

8.2 Workmanship

The quality of workmanship and construction shall be such as to ensure that cylinders are free from injurious defects. The following points shall be taken into account:

- a) the pressure-containing parts shall be of uniform quality and free from defects;
- 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 cylinder shall be free from defects with full weld penetration. The weld shall not have concavity, weld under-cutting or abrupt weld irregularity, nor have any cracks or other defects.

9 Type approval procedure

9.1 General

A technical specification of each new design of cylinder [or cylinder family as defined in f) below] including design drawing, design calculations, material details and heat treatment shall be submitted by the manufacturer to the inspector.

The type approval tests detailed in 9.2 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 compared with an existing approved design when:

- a) it is manufactured in a different manufacturing facility or
- b) it is manufactured by a different process (this includes any major process change) or
- c) it is manufactured from a material of different specification or
- d) it is given a different heat treatment, if applicable or
- 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 or
- f) the overall length of the cylinder has increased by more than 50 % (cylinders with a length:outside diameter ratio less than 3 shall not be used as reference for any new design with this ratio greater than 3) or
- g) the nominal outside diameter of the cylinder has been increased or decreased by more than 1 % of the original design diameter or
- h) an increase in the hydraulic test pressure requires a change in design cylindrical wall thickness.

9.2 Prototype tests

9.2.1 General

Cylinders representative of the prototype design shall be tested as described in 9.2.2 to 9.2.7 inclusive. Prior to subjecting the cylinders to prototype testing, the test cylinders shall be subjected to a pressure equal to the test pressure (p_h) and exhibit no leakage or visible distortion.

9.2.2 Material tests

A certified chemical analysis of the cast shall be obtained from the material manufacturer. In addition, a check analysis shall be performed by the cylinder manufacturer on material representative of the prototype cylinders. The check analysis shall meet the requirements of 5.3.

9.2.3 Tensile tests

9.2.3.1 Tensile tests shall be carried out on material taken from three representative prototype cylinders. These tensile specimens shall be located as shown in Figure 3.

9.2.3.2 Tensile specimens shall be prepared and tested in accordance with ISO 6892. If, due to cylinder size or configuration, the specimen size cannot meet the requirements of ISO 6892, a smaller sample may be used following the guidelines in 7.2 of ISO 4705:1983.

The cylinder manufacturer shall record the tensile strength, yield strength and percentage elongation.

9.2.3.3 All tensile specimens shall exhibit ductile fracture; 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 shall meet the requirements of the design criteria;
- b) for heat-treated and non heat-treated cylinders, the yield strength shall be $\geq R_e$;
- c) for heat-treated and non heat-treated cylinders, the percentage elongation shall meet the requirements of 7.3 a). Percentage 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.

9.2.4 Burst tests

9.2.4.1 Burst tests shall be carried out on a minimum of three representative prototype cylinders.

9.2.4.2 Each cylinder shall be placed on a scale to determine the cylinder tare weight. Each cylinder shall then be filled with fluid to the maximum volume of the cylinder in order 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. The pressure gauging device shall be accurate to within 1 %. The temperature of the pressurizing liquid/gas shall not be less than 10 °C.

9.2.4.4 The procedure for burst testing cylinders shall be as follows.

- a) Test cylinders which have not been heat treated shall be artificially aged by holding the cylinders at a temperature of 100 °C for a minimum of 1 h. After exposure to heat, the cylinders shall be air cooled prior to being filled with liquid/gas.

Where hydraulic bursting 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 test may be conducted. When a pneumatic burst test method is used, all safety precautions and considerations shall be taken to assure the safety of personnel and property.

- b) The test cylinders shall be pressurized to the test pressure (p_h). This pressure shall be held for 30 s. There shall be no decrease in the pressure during the holding period.
- c) The pressure in the cylinder shall then be increased at a rate not exceeding 7 bar/min until the design minimum burst pressure value is achieved. After achieving the design minimum burst pressure, the rate of pressurization may be increased to any convenient value until cylinder bursting occurs.

NOTE As an alternative to steps b) and c), the cylinder may be pressurized from atmospheric pressure to bursting pressure at the rates as described in step c).

- d) A time pressure chart shall be generated during the burst test to record the rate of pressurization, duration of the test and burst pressure of the cylinder being tested.

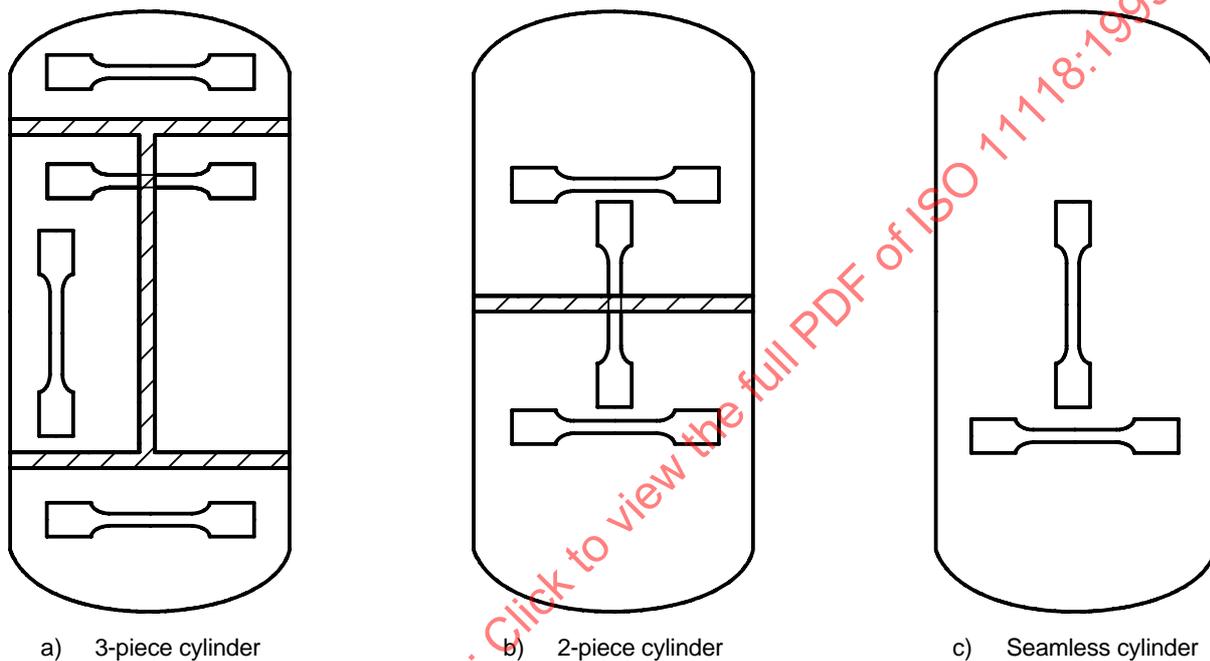


Figure 3 — Location of tensile specimens

9.2.4.5 The acceptance criteria for the burst test shall be as follows.

- a) The burst pressure shall be equal to or greater than two times the test pressure of the cylinder.
- b) 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 location of the failure shall be in the cylindrical shell of the cylinder.
- d) The fracture surface shall exhibit ductile failure.
- e) The cylinder shall remain in one piece under hydraulic bursting.

9.2.5 Drop tests

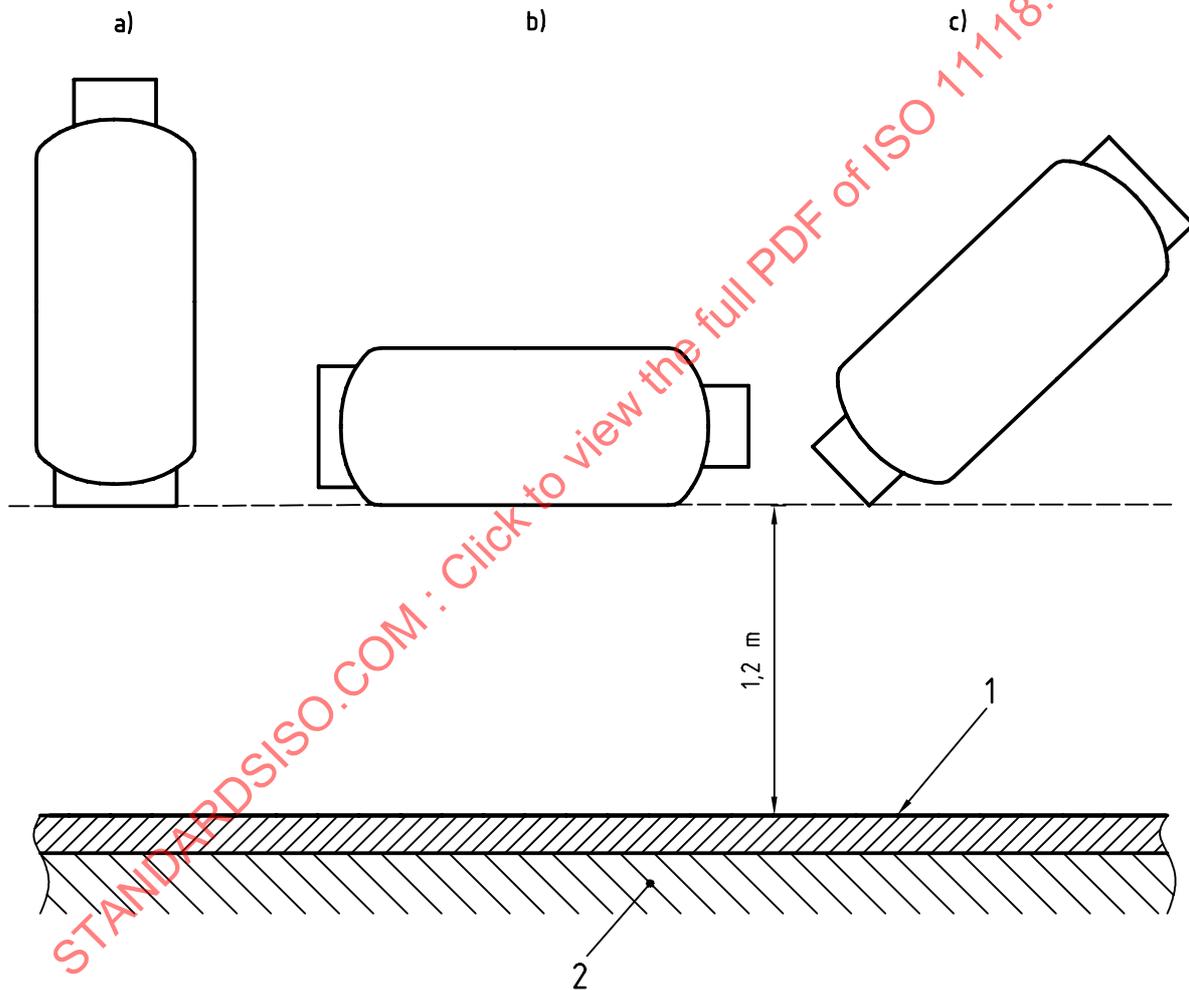
9.2.5.1 Drop tests shall be carried out on a minimum of three representative prototype cylinders. The samples for drop testing shall be representative of the final shipping package (e.g. carton, overpack, cylinder cap).

9.2.5.2 The impact surface shall be a concrete block 1 m × 1 m × 0,1 m, 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. It shall be changed when it is significantly damaged.

9.2.5.3 Cylinders used for liquefied gases shall be filled with water 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 shall be as follows:

- 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 side wall 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 striking the impact surface at a 45° angle as illustrated in Figure 4. c).



Key

- 1 Impact surface
- 2 Concrete block

Figure 4 — Drop tests

9.2.5.4 The acceptance criteria for the drop test shall be as follows.

For cylinders tested as described in clause 9.2.5.3, the cylinder shall exhibit no leakage, the valve shall remain operational and the cylinder shall pass the burst test as described in 9.2.4.

9.2.6 Tests for attachments

Seamless cylinders which are not heat-treated and have had attachments fitted by an application of heat in excess of 400 °C for steel and 150 °C for aluminium shall be examined. The examination shall, as a minimum, include microstructure, hardness and radiography to ensure no detrimental features are present.

9.2.7 Dimension checks

9.2.7.1 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, may be used. The minimum thickness shall be not less than the minimum thickness calculated in 7.2.

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

9.3 Test report

9.3.1 A test report on the prototype design shall be made on all tests detailed in 9.2. In addition, the mechanical (physical) and chemical properties of the material and the thickness of the cylindrical shell shall be included in the report. A copy of the report(s) shall be maintained by the cylinder manufacturer.

9.3.2 The cylinder manufacturer shall maintain copies of the test report(s) for the entire period that the cylinder is being manufactured and for 5 years after manufacturing ceases.

10 Batch tests

10.1 General

A burst test in accordance with 9.2.4 shall be carried out at a frequency of either one cylinder per batch or the sampling frequency specified in Table 1, whichever is greater.

The burst tests shall be conducted on randomly selected cylinders.

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 1 — Sampling frequency

$p_{ms} \cdot V$	Sampling frequency
0 to 50	1/1 000
51 to 300	1/750
301 to 600	1/500
601 to 1 000	1/200

10.2 Failure to meet test requirements

If the cylinder fails to meet any of the requirements of 9.2.4.5, the batch shall be rejected. If the cause for the rejection can be determined and the affected cylinders isolated from the batch, then the remainder of the batch may be requalified by retesting following the procedures of 10.1.

11 Tests on every cylinder — pressure and leak tests

Each cylinder, except those used for burst tests, shall be pressure tested at a pressure of at least the test pressure (p_h), but not more than the lesser of $1,1 \times p_h$ or $(p_h + 10)$ bar, and shall be held at that pressure for a minimum of 30 s.

Pressure testing shall be conducted with the cylinder submerged under water or by any other method giving equally sensitive leak detection. As an alternative, the cylinder shall be pressure tested at test pressure (p_h) and subsequently be leak tested at the time of filling.

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

Cylinders exhibiting any of these defects shall be rejected.

12 Markings

12.1 General

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

12.2 Manufacturing and operational markings

12.2.1 The markings are as follows:

- a) the number of this International Standard, i.e. ISO 11118;
- b) working pressure in bar and test pressure in bar;
- c) water capacity in litres;
- d) the registration number or symbol of the cylinder manufacturing facility;
- e) two-lettered symbol indicating the country of origin in accordance with ISO 3166-1;
- f) the date code of the year and month of manufacture;
- g) the batch serial number;
- h) the UN identification number of the gas.

12.2.2 The markings required by 12.2.1 a) to e) inclusive, shall be in numbers and letters at least 3 mm in height and sequentially displayed, e.g.:

ISO 11118	18/22	15	1001	US
12.2.1a)	12.2.1b)	12.2.1c)	12.2.1d)	12.2.1e)

12.2.3 Date codes and batch markings as required by 12.2.1 f) and g) shall be numbers at least 3 mm in height and sequentially displayed, e.g.:

91-06-0000

12.2.1 f) ————
 12.2.1 g) ————