
**Gas cylinders — Refillable composite
gas cylinders and tubes — Design,
construction and testing —**

Part 2:

**Fully wrapped fibre reinforced composite
gas cylinders and tubes up to 450 l with
load-sharing metal liners**

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*Bouteilles à gaz — Bouteilles à gaz rechargeables en matériau
composite et tubes — Conception, construction et essais —*

ISO 11119-2:2012

*Partie 2: Bouteilles à gaz composites entièrement bobinées renforcées
par des fibres et tubes d'une contenance allant jusqu'à 450 l avec liners
métalliques transmettant la charge*



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Contents

Page

| | |
|---|----|
| Foreword | iv |
| Introduction | v |
| 1 Scope | 1 |
| 2 Normative references | 1 |
| 3 Terms and definitions | 2 |
| 4 Symbols | 4 |
| 5 Inspection and testing | 4 |
| 6 Materials | 4 |
| 6.1 Liner materials | 4 |
| 6.2 Composite materials | 5 |
| 7 Design and manufacture | 5 |
| 7.1 General | 5 |
| 7.2 Design submission | 5 |
| 7.3 Manufacturing | 6 |
| 8 Type approval procedure | 7 |
| 8.1 General requirements | 7 |
| 8.2 Prototype tests | 7 |
| 8.3 New design | 8 |
| 8.4 Design variants | 9 |
| 8.5 Type approval test procedures and criteria | 10 |
| 9 Batch inspection and testing | 22 |
| 9.1 Liner | 22 |
| 9.2 Failure of liner batch tests | 23 |
| 9.3 Overwrap materials | 23 |
| 9.4 Composite cylinder | 23 |
| 9.5 Cylinder failure during type approval or batch testing | 24 |
| 10 Cylinder marking | 25 |
| 10.1 General | 25 |
| 10.2 Additional marking | 25 |
| Annex A (informative) Examples of design approval certificate | 26 |
| Annex B (informative) Specimen test reports | 27 |
| Bibliography | 30 |

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11119-2 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

This edition cancels and replaces ISO 11119-2:2002.

ISO 11119 consists of the following parts, under the general title *Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing*:

- *Part 1: Hoop wrapped fibre reinforced composite gas cylinders and tubes up to 450 l*
 - *Part 2: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners*
 - *Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners*
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The following part is under preparation:

- *Part 4: Fully wrapped fibre reinforced composite gas cylinders with load-sharing welded metal liners*

Introduction

The purpose of this International Standard is to provide a specification for the design, manufacture, inspection and testing of 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 inspection and restrictions currently existing because of lack of definitive International Standards and is not to be construed as reflecting on the suitability of the practice of any nation or region.

This part of ISO 11119 addresses the general requirements on design, construction and initial inspection and testing of pressure receptacles of the *Recommendations on the transport of dangerous goods: Model regulations* developed by the United Nations (Reference [16]).

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Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing —

Part 2:

Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners

1 Scope

This part of ISO 11119 specifies requirements for composite gas cylinders and tubes between 0,5 l and 450 l water capacity, for the storage and conveyance of compressed or liquefied gases.

This part of ISO 11119 applies to type 3 fully wrapped cylinders or tubes with a load-sharing metal liner and composite reinforcement on both the cylindrical portion and the dome ends.

This part of ISO 11119 is limited to cylinders and tubes with composite reinforcement of carbon fibre, aramid fibre or glass fibre (or a mixture thereof) within a matrix.

Cylinders complying with this part of ISO 11119 have a minimum design life of 15 years.

This part of ISO 11119 does not address the design, fitting, and performance of removable protective sleeves.

This part of ISO 11119 does not apply to cylinders with welded liners.

NOTE ISO 11439^[6] applies to cylinders intended for use as fuel containers on natural gas vehicles and ISO 11623^[7] covers periodic inspection and re-testing of composite cylinders.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3341, *Textile glass — Yarns — Determination of breaking force and breaking elongation*

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

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 7225, *Gas cylinders — Precautionary labels*

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

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

ISO 9809-2, *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 1 100 MPa*

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

ISO 10618, *Carbon fibre — Determination of tensile properties of resin-impregnated yarn*

ISO 11119-2:2012(E)

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

ISO 13341, *Gas cylinders — Fitting of valves to gas cylinders*

ISO 13769, *Gas cylinders — Stamp marking*

EN 1964-3, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 3: Cylinders made of seamless stainless steel with an R_m value of less than 1 100 MPa*

ASTM D7269, *Standard test methods for tensile testing of aramid yarns*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. References to cylinders are to include composite tubes as appropriate

3.1

aramid fibre

continuous filaments of aramid laid up in tow form

3.2

autofrettage

pressure application procedure which strains the metal liner past its yield point sufficient to cause permanent plastic deformation, and results in the liner having compressive stresses and the fibres having tensile stresses when at zero internal gauge pressure

3.3

batch

set of homogeneous items or material

NOTE The number of items in a batch can vary according to the context in which the term is used.

3.4

batch of liners

production quantity of up to 200 finished liners successively produced (plus units required for destructive testing) of the same nominal diameter, length, thickness and design, from the same material cast and heat treated to the same conditions of temperature and time

3.5

batch of finished cylinders

production quantity of up to 200 finished cylinders successively produced by the same manufacturing process plus finished cylinders required for destructive testing, of the same nominal diameter, length, thickness and design

3.6

burst pressure

highest pressure reached in a cylinder during a burst test

3.7

carbon fibre

continuous filaments of carbon laid up in tow form

3.8

composite overwrap

combination of fibres and matrix

3.9

dedicated gas service

service in which a cylinder is to be used only with a specified gas or gases

3.10**equivalent fibre**

fibre equivalent to a fibre used in a previously prototype tested cylinder

3.11**equivalent liner**

liner that has certified properties and performance so as to be a direct equivalent to a liner used in an already approved cylinder

3.12**exterior coating**

layers of material applied to the cylinder as protection or for cosmetic purposes

NOTE The coating can be clear or pigmented.

3.14**glass fibre**

continuous filaments of glass laid up in tow form

3.15**liner**

inner portion of the composite cylinder, comprising a metallic vessel, whose purpose is both to contain the gas and transmit the gas pressure to the fibres

3.16**matrix**

material that is used to bind and hold the fibres in place

3.17**load-sharing liner**

liner which has a burst pressure greater than or equal to 5 % of the nominal burst pressure of the finished composite cylinder

3.18**thermoplastic material**

plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.19**thermosetting material**

plastics that, when cured by the application of heat or chemical means, harden permanently into a substantially infusible and insoluble product

3.20**working pressure**

settled pressure of a compressed gas at a reference temperature of 15 °C in a full gas cylinder

3.21**nominal outside diameter**

Diameter of the cylinder specified by the manufacturer for the type approval including tolerances (e.g. $\pm 1\%$)

3.22**type 3 cylinder**

fully wrapped cylinder with a load-sharing metal liner and composite reinforcement on both cylindrical and dome ends.

4 Symbols

Symbols and their designations

| | | |
|-----------|-------------------------------------|-----|
| p_b | burst pressure of finished cylinder | bar |
| p_h | test pressure | bar |
| p_{max} | maximum developed pressure at 65 °C | bar |
| p_w | working pressure | bar |

5 Inspection and testing

This part of ISO 11119 is intended to be used under a variety of national regulatory regimes, but has been written so that it is suitable for use with the conformity assessment system of the *Recommendations on the transport of dangerous goods: Model regulations* developed by the United Nations (Reference [16]). Attention is drawn to requirements in specified relevant national regulations of the country (countries) where the cylinders are intended to be used that might override the requirements given in this part of ISO 11119.

To ensure that the cylinders conform to this part of ISO 11119, they shall be subject to inspection and testing in accordance with Clauses 6, 7, 8, and 9 by an inspection body (hereafter referred to as “the inspector”) authorized to do so. Example forms of certificates that can be used are shown in Annexes A and B.

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

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6 Materials

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6.1 Liner materials

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6.1.1 The liner materials shall conform in all relevant respects to the appropriate standard:

- a) seamless steel liners: ISO 9809-1, ISO 9809-2 or ISO 9809-3, as appropriate;
- b) seamless stainless steel liners: EN 1964-3;
- c) seamless aluminium alloy liners: ISO 7866.

Relevant sections are those covering materials, thermal treatments, neck design, construction and workmanship, and mechanical tests. This excludes the design requirements, since these are specified by the manufacturer for the design of the composite cylinder (see 7.2.2).

6.1.2 The materials used shall be of uniform and consistent quality. The composite cylinder manufacturer shall verify that each new batch of materials has the correct properties and is of satisfactory quality, and shall maintain records so that the cast of material and the heat treatment batch (where applicable) used for the manufacture of each cylinder can be identified.

6.1.3 The liner shall be manufactured from a metal or alloy suitable for the gas to be contained in accordance with ISO 11114-1.

6.1.4 When a neck ring is provided, it shall be of a material compatible with that of the cylinder, and shall be securely attached by a method appropriate to the liner material.

6.2 Composite materials

6.2.1 The overwrap materials shall be carbon fibre or aramid fibre or glass fibre or any mixture thereof.

6.2.2 The matrix shall be a polymer suited to the application, environment, and intended life of the product.

6.2.3 The supplier of the filament material and the matrix system component materials shall provide sufficient documentation for the composite cylinder manufacturer to be able to identify fully the batch of materials used in the manufacture of each cylinder.

6.2.4 The materials used shall be of uniform and consistent quality. The composite cylinder manufacturer shall verify that each new batch of materials has the correct properties and is of satisfactory quality, and maintain records from which the batch of materials used for the manufacture of each cylinder can be identified. A certificate of conformity from the material manufacturer is considered acceptable for the purposes of verification.

6.2.5 Batches of materials shall be identified and documented to the satisfaction of the inspector.

7 Design and manufacture

7.1 General

7.1.1 A Type 3 fully-wrapped composite gas cylinder with load-sharing liner shall comprise:

- a) an internal metal liner, which carries part of the longitudinal and circumferential load;
- b) a composite overwrap formed by layers of continuous fibres in a matrix;
- c) an optional external protection system.

Where necessary, care shall be taken to ensure that there is no adverse reaction between the liner and the reinforcing fibre by the application of a suitable protective coating to the liner prior to the wrapping process.

7.1.2 Cylinders shall be designed with one or two openings along the central axis only. Threads shall extend completely through the neck or have sufficient threads to allow full engagement of the valve.

The cylinder can also include additional parts (e.g. neck rings, bases).

7.1.3 Examples of certificates are shown in Annexes A and B.

7.2 Design submission

7.2.1 The design submission for each new design of cylinder shall include a detailed drawing, along with documentation of the design including manufacturing and inspection particulars as detailed in 7.2.2, 7.2.3, and 7.2.4.

7.2.2 Documentation for the liner shall include (but not be limited to):

- a) material, including limits of chemical analysis;
- b) dimensions, minimum thickness, straightness, and out-of-roundness, with tolerances;
- c) process and specification of manufacture;
- d) heat treatment, temperatures, duration, and tolerances;
- e) inspection procedures (minimum requirements);

- f) material properties including minimum mechanical properties and hardness ranges, where applicable;
- g) minimum design burst pressure;
- h) dimensional details of valve threads and any other permanent features.

7.2.3 Documentation for the composite overwrap shall include (but not be limited to):

- a) fibre material, specification, and mechanical properties requirements;
- b) minimum composite thickness ;
- c) thermosetting matrix — specifications (including resin, curing agent and accelerator), and resin bath temperature where applicable;
- d) thermoplastic matrix system — main component materials, specifications and process temperatures;
- e) overwrap construction including the number of strands used, number of layers, layer orientation, and tensioning of the fibre at wrapping (where applicable);
- f) curing process, temperatures, duration, and tolerances, where applicable.

7.2.4 Documentation for the composite cylinder shall include (but not be limited to):

- a) nominal water capacity, in litres, under ambient conditions;
- b) dimensions with tolerances
- c) list of intended contents, if intended for dedicated gas service;
- d) test pressure, p_h ;
- e) working pressure, p_w (if applicable), that shall not exceed $0,67 \times p_h$;
- f) maximum developed pressure at 65 °C for specific dedicated gas(es), p_{max} ;
- g) minimum design burst pressure;
- h) design life in years, although cylinders with a test pressure of less than 60 bar shall have a non-limited design life;
- i) autofrettage pressure and approximate duration (where applicable);
- j) nominal mass of the finished composite cylinder, including tolerances;
- k) details of components which are permanently attached and form part of the qualified design (neck rings, protective boots, etc.).

7.3 Manufacturing

7.3.1 The liner shall be manufactured in accordance with the manufacturer's design (see 7.2.2) and the International Standard for the relevant metallic material (as listed in 6.1.1).

7.3.2 The composite cylinder shall be fabricated from a load-sharing liner fully overwrapped with layers of continuous fibres in a matrix applied under a controlled tension to develop the design composite thickness specified in 7.2.3.

Liners can be stripped and re-wound provided that the overwrap has not been cured. The liner shall not be overwrapped if it has been damaged or scored by the stripping process.