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

## Part 4:
## Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 L with load-sharing welded metallic liners

*Bouteilles à gaz composites — Spécifications et méthodes d'essai*

ICS: 23.020.30

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# Foreword

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

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

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

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

ISO 11119-4 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

This is a first edition.

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 composite gas cylinders and tubes up to 450L*

*Part 2: Fully-wrapped fibre reinforced composite gas cylinders and tubes up to 450L with load-sharing metal liners*

*Part 3: Fully-wrapped fibre reinforced composite gas cylinders and tubes up to 450L with non-load-sharing metallic or non-metallic liners*

*Part 4: Fully-wrapped fibre reinforced composite gas cylinders and tubes up to 450L with load-sharing welded metallic liners*

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# Introduction

The purpose of this part of ISO 11119 is to provide a specification for the design, manufacture, inspection and testing of a cylinder for world-wide usage. The objective is to balance design and economic efficiency against international acceptance and universal utility.

ISO 11119 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.

Some procedures and tests may require that precautions be taken for the health and/or safety of operator(s). Safety, health and environmental concerns are not addressed and should be addressed by those who wish to implement this standard.

ISO 11119-4 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 UN Model Regulations for the Transportation of Dangerous Goods. 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 International Standard

Annexes A and B of this part of ISO 11119 are for information only.

Annex C of this part of ISO 11119 is normative.

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# Gas cylinders – Refillable composite gas cylinders and tubes — Design, construction and testing — Part 4: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450L with load-sharing welded metallic liners

## 1. Scope

This part of ISO 11119 specifies requirements for composite gas cylinders and tubes with load sharing welded liners between 0.5 l and 450 l water capacity and a maximum test pressure of 450 bar, for the storage and conveyance of compressed or liquefied gases.

The cylinders are constructed in the form of a welded stainless steel liner or welded ferritic steel liner or welded aluminum alloy liner and- over-wrapped with carbon fibre or aramid fibre or glass fibre (or a mixture thereof) in a matrix to provide longitudinal and circumferential reinforcement.

The cylinders and tubes in this standard are 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.

Cylinders produced in accordance with the standard have a minimum design life of 15 years. Cylinders with test pressure up to 60 bar have an unlimited design life.

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 seamless liners. For seamless liners ISO11119-2 applies

NOTE ISO 11623 covers periodic inspection and re-testing of composite cylinders.

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## 2. Normative references

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

ISO 75.3; *Plastics -- Determination of temperature of deflection under load -- Part 3: High-strength thermosetting laminates and long-fibre-reinforced plastics*

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

ISO 4706, Gas cylinders -- Refillable welded steel cylinders -- Test pressure 60 bar and below ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

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

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)*

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ISO 8521; *Plastics piping systems -- Glass-reinforced thermosetting plastics (GRP) pipes -- Test methods for the determination of the apparent initial circumferential tensile strength*

ISO 10042; *Welding -- Arc-welded joints in aluminium and its alloys -- Quality levels for imperfections*

ISO 10618: *Carbon Fibre – Determination of tensile properties of resin impregnated yarn*

ISO 10460; *Gas cylinders -- Welded carbon-steel gas cylinders -- Periodic inspection and testing*

ISO 10464; *Gas cylinders -- Refillable welded steel cylinders for liquefied petroleum gas (LPG) -- Periodic inspection and testing*

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

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

ISO 13769, *Gas cylinders — Stampmarking*

ISO 13919-1; *Welding - Electron and laser-beam welded joints - Guidance on quality levels for imperfections - Part 1: Steel*

*ISO 13919-2; Welding - Electron and laser-beam welded joints - Guidance on quality levels for imperfections - Part 2: Aluminium and its weldable alloys*

ISO 14130 – *Fibre-reinforced plastic composites -- Determination of apparent interlaminar shear strength by short-beam method*

ISO 18172-2, *Gas cylinders -- Refillable welded stainless steel cylinders -- Part 2: Test pressure greater than 6 MPa*

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

ISO/CD 21172-1 – *Gas cylinders – Welded steel pressure drums for the transport of gases. Design and construction. Part 1: Capacities up to 1000 litres*

ASTM D2290*, Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe*

ASTM D2291; *Standard Practice for Fabrication of Ring Test Specimens for Glass-Resin Composites*

ASTM D2343; *Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics*

ASTM D2344*; Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*

ASTM D4018; *Standard Test Methods for Properties of Continuous Filament Carbon and Graphite Fiber Tows*

ASTM D3418; *Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry*

ASTM D2196; *Standard Test M*ethods for *Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer*

EN14638-3, *Transportable gas cylinders. Refillable welded receptacles of a capacity not exceeding 150 litres. Welded carbon steel cylinders made to a design justified by experimental methods*

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## 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 (if applicable) 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 ($pb$) or liner ($pb_l$) during a burst test

**3.7**
**calculated linerproof pressure**
pressure used for the liner integrity test and derived from the test pressure of the relevant liner design standard

NOTE The liner design standards are given in table 1.

**3.8**
**carbon fibre**
continuous filaments of carbon laid up in tow form

**3.9**
**composite overwrap**
combination of fibres and matrix

**3.10**
**dedicated gas service**
service in which a cylinder is to be used only with a specified gas or group of gases

**3.11**
**equivalent fibre**
fibre equivalent to a fibre used in a previously prototype tested cylinder

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**3.12**
**equivalent liner**
-equivalent liners are manufactured from raw materials with the same specification, using the same process of manufacture and having the same physical structure and where the average tensile strength and modulus is within ± 5 % of the approved cylinder design

**3.13**
**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. +/- 1%)

**3.22**
**type 3 cylinder**
fully wrapped cylinder with a load sharing metal liner and composite reinforcement on both cylindrical and dome ends.

**3.23**
**test pressure (ph)**
required pressure applied during the pressure test of the composite cylinder

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## 4. Symbols

Symbols and their designations

| Symbol | Designation | Unit |
|---|---|---|
| $p_b$ | 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 |
| *pbl* | Burst pressure of the liner | |
| *N* | Number of cycles with pressurization to test pressure | |
| *Nd* | Number of cycles with a pressurization to maximum developed pressure | |
| *Y* | Number of years of design life | |
| *pl* | Calculated liner proof pressure for liner integrity test | |

## 5. Inspection and testing

To ensure that the cylinders conform to this part of ISO 11119, they shall be subject to the requirements, 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

### 6.1 Liner Materials

**6.1.1** The liner materials shall conform in all relevant aspects to the appropriate standards (as per table 1).

**6.1.2** Relevant sections are those covering materials, thermal treatments, neck design, construction and workmanship and, mechanical tests. Design requirements are excluded since these are specified by the manufacturer for the design of the composite cylinder (7.2. 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 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 required to be manufactured from a metal or alloy suitable for the gas to be contained as required by 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.

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**Table 1 — Liner material requirements**

| Type | Type of liner | Liner material | Liner heat treatment | Applicable standard | Relevant sections of the applicable standard | Capacity |
|---|---|---|---|---|---|---|
| Cylinders | Welded steel liner | Carbon steel | Yes | ISO 4706:2008 | 5, 6.3, 8, 9 | Up to 150L |
| | | | No | EN 14638-3:2010 | 4, 5.4,6,8 | Up to 150L |
| | | Stainless steel | As defined in the standard (yes or no) | ISO 18172-2:2007 | 4,5.6,6,8 | Up to 150L |
| | Welded Aluminium Alloy liner | Aluminium alloy | | ISO 20703:2006 | 4,5.4,6,7 | Up to 150L |
| Drums | Welded steel drums | Carbon steel, austenitic stainless steel | | [ISO/CD 21172-1] | ? | 150 up to 450L |

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