INTERNATIONAL STANDARD

ISO 11119-3

Second edition
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Gas cylinders — Refillable composite gas cylinders and tubes

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

Bouteilles à gaz — Bouteilles à gaz rechargeables en matériau composite et tubes

Partie 3: Bouteilles à gaz composites entièrement bobinées renforcées par des fibres et tubes d'une contenance allant jusqu'à 450 l avec liners métalliques ou non métalliques ne transmettant pas la charge

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

This second edition cancels and replaces the first edition (ISO 11119-3:2002), which has been technically revised.

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 450L with non-load-sharing metallic or non-metallic liners*

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 ISO 11119 is to provide a specification for the design, manufacture, inspection and testing of cylinders 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.

This part of ISO 11119 addresses the general requirements on design, construction and initial inspection and testing of pressure receptacles of the United Nations "*Recommendations on the Transport of Dangerous Goods Model Regulations*."

Gas cylinders — Refillable composite gas cylinders and tubes —

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

1 Scope

This part of ISO 11119 specifies requirements for composite gas cylinders up to 150 l water capacity and composite tubes above 150 l water capacity and up to 450 l water capacity, for the storage and conveyance of compressed or liquefied gases.

The cylinders and tubes in this part of ISO 11119 are

a) Type 4 Fully Wrapped Cylinders or Tubes with a non-load-sharing liner and composite reinforcement on both the cylindrical portion and the dome ends, and

b) Type 5 Fully Wrapped Cylinders or Tubes without liners (including cylinders without liners manufactured from two parts joined together) and with a test pressure of less than 60 bar.

The cylinders are constructed:

1) in the form of a disposable mandrel overwrapped with carbon fibre or aramid fibre or glass fibre (or a mixture thereof) in a resin matrix to provide longitudinal and circumferential reinforcement;

2) in the form of two filament wound shells joined together.

Cylinders and tubes manufactured and tested to this part of ISO 11119 are not intended to contain toxic, oxidizing or corrosive gases.

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

Cylinders and tubes manufactured and tested to 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.

NOTE 1 References to cylinders in this International Standard include composite tubes if appropriate.

NOTE 2 ISO 11439 applies to cylinders intended for use as fuel containers on natural gas vehicles and ISO 11623 covers periodic inspection and re-testing of composite cylinders.

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 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

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

ISO 7225, *Gas cylinders — Precautionary labels*

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

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

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*

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.

NOTE References to cylinders include composite tubes if appropriate.

3.1
aramid fibre
continuous filaments of aramid laid up in tow form

3.2
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.

3.3
batch of metallic liners
quantity of liners of the same nominal diameter, length, thickness and design, made successively from the same batch of materials, subjected to the same manufacturing process and heat treated to the same conditions of temperature and time

3.4
batch of non-metallic liners
quantity of liners of the same nominal diameter, length, thickness and design, made successively from the same batch of materials and subjected to the same manufacturing process

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 liner or 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 manufactured from the same nominal raw materials, using the same process of manufacture and having the same physical structure and the same nominal physical properties, and where the average tensile strength and modulus is within ± 5 % of the fibre properties in an approved cylinder design

3.11
equivalent liner
liner that are manufactured from the same nominal raw materials, using the same process of manufacture and having the same physical structure and the same nominal physical properties as in an approved cylinder design

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.

3.13
glass fibre
continuous filaments of glass laid up in tow form

3.14
liner
inner portion of the composite cylinder, comprising a metallic or non-metallic vessel, whose purpose is both to contain the gas and transmit the gas pressure to the fibres

3.15
matrix
material that is used to bind and hold the fibres in place

3.16
non-load-sharing liner
liner that has a burst pressure less than 5 % of the nominal burst pressure of the finished composite cylinder

3.17
thermoplastic material
plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.18
thermosetting material
plastics that, when cured by the application of heat or chemical means, harden permanently into a substantially infusible and insoluble product

3.19
nominal outside diameter
diameter of the cylinder specified by the manufacturer for the type approval including tolerances (e.g. +/- 1 %)

3.20
Type 4 cylinder
fully wrapped cylinder with a non-load sharing liner and composite reinforcement on both the cylindrical portion and the dome ends

3.21
Type 5 cylinder
fully wrapped cylinder without a liner and with composite reinforcement on both the cylindrical portion and dome ends

3.22
working pressure
settled pressure of a compressed gas at a reference temperature of 15 °C in a full gas cylinder

4 Symbols and units

Symbols and their designations

Symbol	Designation	Unit
p_{bl}	Burst pressure of liner	bar
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

ISO 11119-3 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.

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.

6 Materials

6.1 Liner materials

6.1.1 The liner (including metal boss) shall be manufactured from a material suitable for the gas to be contained, as specified in ISO 11114-1 and ISO 11114-2. Metal bosses attached to a non-metallic liner shall fulfil the performance requirements of this document.

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 maintain records from which the batch of materials used for the manufacture of each cylinder can be identified.

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 and, for cylinders manufactured from two halves, the adhesive, shall be a polymer suited to the application, environment and intended life of the product.

6.2.3 The suppliers of the filament material, the matrix component materials and, if applicable, the adhesive component material 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 conformance 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 4 fully-wrapped composite gas cylinder with non-load-sharing metallic or non-metallic liner shall comprise of:

a) an internal metal or non-metallic liner which carries no significant load;

b) metallic boss(es) for thread connections, where these are part of the design;

c) a composite overwrap formed by layers of continuous fibres in a matrix and

d) 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 A Type 5 fully-wrapped cylinder with a test pressure of less than 60 bar can be manufactured either:

a) in the form of a disposable mandrel overwrapped with carbon fibre or aramid fibre or glass fibre (or a mixture thereof) in a matrix to provide longitudinal and circumferential reinforcement or;

b) in the form of two filament wound shells overwrapped with carbon fibre or aramid fibre or glass fibre (or a mixture thereof) in a matrix to provide longitudinal and circumferential reinforcement joined together.

7.1.3 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.

7.1.4 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 and metal boss(es) shall include (but not be limited to):

a) material(s), 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;

g) dimensional details of valve threads and any other permanent features;

h) method of sealing boss to liner for bonded bosses.

7.2.3 Documentation for 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 and layer orientation and tensioning of the fibre at wrapping (where applicable);

f) curing process, temperatures, duration and tolerances;

g) adhesive system, main components and specifications where applicable;

h) adhesive system, curing agent, materials and specifications where applicable;

i) adhesive system, accelerator, materials and specifications where applicable;

j) for cylinders without liners where comprised of two wound shells, dimensions of adhesive bond (length, angle of bond, thickness of adhesive).

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

a) nominal water capacity in litres at ambient conditions;

b) list of intended contents if intended for dedicated gas service;

c) working pressure, p_w (if applicable) that shall not exceed 2/3 times test pressure;

d) test pressure, p_h;

e) maximum developed pressure at 65 °C for specific dedicated gas(es), p_{max};

f) minimum design burst pressure;

g) design life in years; cylinders with a test pressure of less than 60 bar shall have a non-limited design life;

h) nominal weight of the finished composite cylinder, including tolerances;

i) for cylinders without liners, the method of sealing the boss to cylinder (if applicable);

j) details of components which are permanently attached and form part of the qualified design (e.g. neck rings, protective boots etc).

7.3 Manufacturing

7.3.1 The liner and metal bosses, where incorporated, shall be manufactured in accordance with the manufacturer's design (see 7.2.2).

7.3.2 The composite cylinder shall be fabricated from a non-load-sharing liner, or fabricated on a disposable mandrel, fully over-wrapped with layers of continuous fibres in a matrix applied under controlled tension to develop the design composite thickness as 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 over-wrapped if it has been damaged or scored by the stripping process.

For cylinders without liners, manufactured from two parts joined together, the individual parts shall be wound to develop the required composite thickness before being joined with appropriate adhesive.

7.3.3 After wrapping is completed the composite shall be cured (if appropriate) using a controlled temperature profile as specified in the documentation in 7.2.3. The maximum temperature shall be such that the mechanical properties of the liner material, if fitted, and composite overwrap are not adversely affected.

NOTE If cylinders are subjected to fibre tensioning during wrapping, the tensioning shall be recorded or monitored.

8 Type approval procedure

8.1 General requirements

Each new cylinder design shall be submitted by the manufacturer to the inspector. The type approval tests detailed in 8.2 shall be performed, under the supervision of the inspector, on each new cylinder design or design variant.

8.2 Prototype tests

8.2.1 A minimum of 30 cylinders that are representative of the new design shall be made available for prototype testing. Upon successful completion of all prototype tests, the remaining untested cylinders from the prototype qualification batch can be used for service.

