INTERNATIONAL STANDARD

ISO 11119-1

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Gas cylinders of composite construction — Specification and test methods —

Part 1: Hoop wrapped composite gas cylinders

Bouteilles à gaz composites — Spécifications et méthodes d'essai —
Partie 1: Bouteilles à gaz frettées en matériau composite

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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.

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 part of ISO 11119 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11119-1 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

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ISO 11119 consists of the following parts, under the general title *Gas cylinders of composite construction — Specification and test methods*:

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— *Part 1: Hoop wrapped composite gas cylinders*

— *Part 2: Fully wrapped fibre reinforced composite gas cylinders with load-sharing metal liners*

— *Part 3: Fully wrapped fibre reinforced composite gas cylinders with non-metallic and non-load-sharing metal liners*

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

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Introduction

The purpose 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 should not be construed as reflecting on the suitability of the practice of any nation or region.

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Gas cylinders of composite construction — Specification and test methods —

Part 1:
Hoop wrapped composite gas cylinders

1 Scope

This part of ISO 11119 specifies requirements for composite gas cylinders up to and including 450 litres water capacity, for the storage and conveyance of compressed or liquefied gases with test pressures up to and including 650 bar [1)]. The cylinders are constructed in the form of a seamless metallic liner over-wrapped with carbon fibre or aramid fibre or glass fibre (or a mixture thereof) in a resin matrix, or steel wire, to provide circumferential reinforcement.

This part of ISO 11119 addresses cylinders with a design life from 10 a to non-limited life. For cylinders with a design life in excess of 15 a, and in order for these cylinders to remain in service beyond 15 a, requalification of these cylinders is recommended.

This part of ISO 11119 does not address the design, fitting and performance of removable protective sleeves. Where these are fitted, they should be considered separately.

NOTE 1 ISO 11439 applies to cylinders intended for use as fuel containers on natural gas vehicles.

NOTE 2 ISO 11623 covers periodic inspection and retesting of composite cylinders.

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2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 11119. 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 ISO 11119 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 6506-1:1999, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6508-1:1999, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature*

ISO 7225:1994, *Gas cylinders — Precautionary labels*

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

1) 1 bar = 10^5 Pa.

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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 1 100 MPa*

ISO 9809-2:2000, *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 11114-1:1997, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11439:2000, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*

ISO 13341:1997, *Transportable gas cylinders — Fitting of valves to gas cylinders*

ISO 13769:— [2)], *Gas cylinders — Stamp marking*

EN 1964-3:2000, *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 D 2343, *Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics*

ASTM D 4018, *Standard Test Methods for Properties of Continuous Filament Carbon and Graphite Fiber Tows*

SACMA SRM 16R-94, *Recommended Test Method for Tow Tensile Testing of Carbon Fibers*

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3 Terms and definitions

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For the purposes of this part of ISO 11119, the following terms and definitions apply.

3.1
aramid fibre
continuous filaments of aramid laid up in tow form, used for reinforcement

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
collective term for a set of homogeneous items or material

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

3.3.1
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

2) To be published.

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3.3.2
batch of finished cylinders
production quantity of up to 200 finished cylinders successively produced (plus finished cylinders required for destructive testing), of the same nominal diameter, length, thickness and design

NOTE The batch of finished cylinders may contain different batches of liners, fibres and matrix materials.

3.4
burst pressure
highest pressure reached in a cylinder during a burst test

3.5
carbon fibre
continuous filaments of carbon laid up in tow form, used for reinforcement

3.6
composite overwrap
the combination of fibres and matrix

3.7
dedicated gas service
service in which a cylinder is to be used only with specified gas or gases

3.8
equivalent fibre or wire
fibre or wire 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 or wire properties in an approved cylinder design

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NOTE Carbon fibres made from the same precursor can be equivalent, but aramid, carbon and glass fibres are not equivalent.

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3.9
equivalent liner
liner equivalent to a liner in a previously prototype tested cylinder when the liner is of the prototype tested design except that it is given a heat treatment outside the limits specified in the prototype tested design

3.10
exterior coating
layers of material applied to the cylinder as protection or for cosmetic purposes

NOTE The coating may be clear or pigmented.

3.11
hoop wrapped cylinder
cylinder with reinforcement to take circumferential stress

3.12
glass fibre
continuous filaments of glass laid up in tow form, used for reinforcement

3.13
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

3.14
matrix
material which is used to bind and hold the fibres in place

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3.15
steel wire
steel wire wound under tension

4 Symbols

See Table 1.

Table 1 — Symbols and their designations

Symbol	Designation	Unit
p_b	Burst pressure of finished cylinder	bar
p_{bl}	Burst pressure of liner	bar
p_h	Test pressure	bar
p_{max}	Maximum developed pressure at 65°C	bar

5 Inspection and testing

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Evaluation of conformity is required to be performed in accordance with the relevant regulations of the country(ies) where the cylinders are used. In order 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 authorized inspection body (hereafter referred to as “the inspector”) recognized in the country(ies) of use. The inspector shall be competent for the inspection of cylinders.

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6 Materials

6.1 Liner materials

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

a) seamless steel liners: ISO 9809-1 or ISO 9809-2, as appropriate;

b) seamless stainless steel liners: EN 1964-3;

c) seamless aluminium alloy liners: ISO 7866.

This excludes the design requirements, since these are specified by the manufacturer for the design of the composite cylinder (see 7.2.2).

NOTE For liners with a water capacity > 150 l the relevant sections of the above standards also apply.

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 from which the batch of materials used for the manufacture of each cylinder can be identified. A certificate of conformance from the liner material manufacturer is considered acceptable for the purposes of verification.

6.1.3 The cast shall be identified to the satisfaction of the inspector.

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6.1.4 The liner shall be manufactured from a metal or alloy suitable for containing the gas (see ISO 11114-1). Furthermore the liner material shall be evaluated by the manufacturer as suitable for the specific application. If the liner material is not covered by ISO 11114-1 for a particular gas/commodity, the responsibility for the approval of material selection should reside with the authority having jurisdiction in the country of use.

6.1.5 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 filament materials shall be carbon fibre or aramid fibre or glass fibre (or any mixture thereof), or steel wire.

6.2.2 The resin matrix shall be a polymer suited to the application, environment and intended life of the product; e.g., epoxy or modified epoxy with amine or anhydride curing agent, vinyl esters and polyesters.

6.2.3 The supplier of the filament material and the resin system component material or steel wire 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.

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6.2.6 The manufacturer shall ensure there is no adverse reaction between the liner and the reinforcing fibre or steel wire by the application of a suitable protective coating to the liner prior to the wrapping process (if necessary).

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7 Design and manufacture

7.1 General

7.1.1 A hoop wrapped composite gas cylinder shall comprise the following parts:

— an internal metal liner, which carries the total longitudinal load and a substantial circumferential load and either

— a composite overwrap formed by layers of continuous fibres in a matrix or

— a composite overwrap formed by layers of continuous fibres in a matrix, or a composite overwrap formed by steel wire reinforcement and

— an optional exterior coating to provide external protection. When this is an integral part of the design it shall be permanent.

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

7.1.3 The cylinder may also include additional parts such as rings, bases, etc.

7.1.4 The composite cylinder shall be certified by the inspector. The inspector shall certify that the design, manufacture, inspection and testing were carried out in accordance with this part of ISO 11119. Example forms of certificates are shown in annexes A and B.

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7.1.5 The cylinders shall be designed for high reliability under sustained load and cyclic loading. Therefore it is necessary to take account of the properties of the individual composite fibres and to establish their respective minimum fibre stress ratios.

The fibre stress ratio is defined as the fibre stress at calculated design minimum burst pressure divided by the fibre stress at × 2/3 test pressure.

The minimum fibre stress ratios shall be as follows:

— for glass — 2,5

— for aramid — 2,4

— for carbon — 2,4

7.2 Design submission

7.2.1 The design submission for each new cylinder shall include a detailed drawing, along with documentation of the design including stress analysis, manufacturing and inspection particulars as detailed in 7.2.2, 7.2.3, 7.2.4 and 7.2.5.

7.2.2 Documentation for the liner shall include:

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 (mechanical properties requirements);

g) minimum design burst pressure;

h) dimensional details of valve threads and any other permanent features.

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7.2.3 Documentation for the composite overwrap shall include:

a) fibre/wire material, specification and mechanical properties requirements;

b) fibre/wire construction, strand geometry and treatment;

c) resin system, main components and resin bath temperature where applicable;

d) resin system, curing agent, materials and specifications where applicable;

e) resin system, accelerator, materials and specifications where applicable;

f) overwrap construction including the number of strands used;

g) curing process, temperatures, duration and tolerances.

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