INTERNATIONAL STANDARD

ISO 11119-3

First edition
2002-09-15

Gas cylinders of composite construction — Specification and test methods —

Part 3: Fully wrapped fibre reinforced composite gas cylinders with non-load-sharing metallic or non-metallic liners

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

Partie 3: Bouteilles à gaz composites entièrement bobinées renforcées par des liners non métalliques ou des liners métalliques ne transmettant pas la charge

Reference number
ISO 11119-3:2002(E)

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Printed in Switzerland

Contents

Page

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

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

— *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-load-sharing metallic or non-metallic liners*

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

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

Gas cylinders of composite construction — Specification and test methods —

Part 3: Fully wrapped fibre reinforced composite gas cylinders with non-load-sharing metallic or non-metallic liners

1 Scope

This part of ISO 11119 specifies requirements for composite gas cylinders up to and including 450 l water capacity, for the storage and conveyance of compressed or liquefied gases with test pressures ranging up to and including 650 bar [1)].

This part of ISO 11119 applies to:

a) Fully wrapped composite cylinders with a non-load-sharing metallic or non-metallic liner (i.e. a liner that does not share the load of the overall cylinder design) and a design life from 10 years to non-limited life. For cylinders with a design life in excess of 15 years, re-qualification is recommended in order for these cylinders to remain in service beyond 15 years.

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

b) Composite cylinders without liners (including cylinders without liners manufactured from two parts joined together) and with a test pressure of less than 60 bar. For cylinders with a design life in excess of 15 years, re-qualification is recommended in order for these cylinders to remain in service beyond 15 years.

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.

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

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

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.

1) 1 bar = 10^5 Pa.

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 527-1:1993, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2:1993, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

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

ISO 11114-2:2000, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-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 13769:2002, *Gas cylinders — Stamp marking*

ASTM D 2343-95, *Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns and Rovings Used in Reinforced Plastics*

ASTM D 4018-99, *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*

3 Terms and definitions

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
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
batch of metallic liners
quantity of liners 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

3.4
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 (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.

3.6
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, used for reinforcement

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

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

3.11
equivalent liner
liner equivalent to a liner in a previously prototype tested cylinder when any of the following apply:

— the liner is of the prototype tested design except that it has been manufactured in a different factory;

— the liner is of the prototype tested design except that it has been manufactured using a significantly different process to that used to produce the prototype tested design;

— the liner is of the prototype tested design except that it has been given a heat treatment outside the limits specified in the prototype tested design

3.12
exterior coating
layers of material applied to the cylinder as protection or for cosmetic purposes

NOTE The coating may be clear or pigmented.

3.13
fully-wrapped cylinder
cylinder reinforced with fibres in a resin matrix to take both circumferential and longitudinal stress

3.14
glass fibre
continuous filaments of glass laid up in tow form, used for reinforcement

3.15
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

3.16
matrix
material which is used to bind and hold the fibres in place

3.17
non-load-sharing liner
liner which has a burst pressure less than 5 % of the nominal burst pressure of the finished composite cylinder

4 Symbols

See Table 1.

Table 1 — 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

5 Inspection and testing

Evaluation of conformance is required to be performed in accordance with the relevant regulations of the countries 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 countries of use. The inspector shall be competent for inspection of composite cylinders.

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. See ISO 11114-1 and ISO 11114-2. Furthermore, the liner materials shall be evaluated by the manufacturer and approved by the inspector as suitable for the specific application. Metal bosses attached to a non-metallic liner shall fulfil the performance requirements of this part of ISO 11119.

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. A certificate of conformance from the liner material manufacturer is considered acceptable for the purposes of verification.

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 resin matrix and, for cylinders manufactured in two halves, the adhesive, 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 or polyesters.

6.2.3 The suppliers of the filament material, the resin matrix component material 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.

6.2.6 The manufacturer shall 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 (if necessary).

7 Design and manufacture

7.1 General

7.1.1 A fully-wrapped composite gas cylinder with non-load-sharing metallic or non-metallic liner or no liner shall comprise the following parts:

— for cylinders with a liner, an internal metal or non-metallic liner which carries no significant load;

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

— a composite overwrap formed by layers of continuous fibres in a matrix; when no liner is used this overwrap may be manufactured in two halves subsequently joined together;

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

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

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 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. Examples of certificates are shown in annexes A and B.

7.1.4 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 times test pressure.

The minimum fibre stress ratios shall be as follows:

— glass 3,4

— aramid 3,1

— carbon 2,4

7.1.5 For cylinders without liners and which are manufactured from two parts joined together, the following minimum design requirements shall be met:

— bond line angle of joint shall be less than 10°;

— adhesive thickness shall be less than 0,25 mm;

— the length (width) of the adhesive joint shall be greater than or equal to 10 times the minimum wall thickness of the cylindrical part.

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 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 and metal boss(es) shall include:

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:

a) fibre material, specification and mechanical properties requirements;

b) fibre 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 and details of pre-stressing where applicable;

g) curing process, temperatures, duration and tolerances;

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

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

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

k) 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:

a) water capacity in litres;

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

c) composite cylinder test pressure, p_h;

d) working pressure, p_w (if applicable) not exceeding 2/3 times test pressure;

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

f) design minimum burst pressure [see 8.5.3.2)];

g) tensioning of the fibre at winding (where applicable);

h) design life in years;

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

7.2.5 Stress analysis shall be carried out and documentation shall be provided in accordance with the following.

The stresses in the composite material(s) and in the liner shall be calculated using appropriate finite element stress analysis or other stress analysis programmes, which take account of the non-linear material behaviour of the liner. The nominal thickness and nominal properties of the respective materials shall be used for the calculations.

A table summarizing the stresses at 2/3 times test pressure, test pressure and design minimum burst pressure shall be provided. The fibre stress ratio(s) for the design shall exceed those stated in 7.1.4.

NOTE There is no standardized calculation method for the stress analysis. Therefore the objective of this clause is to demonstrate only that the design stress ratios have been met.