INTERNATIONAL STANDARD

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

Part 4: Fully wrapped fibre reinforced composite gas cylinders up to 150 l with load-sharing welded metallic liners

Bouteilles à gaz — Bouteilles à gaz rechargeables en matériau composite et tubes — Conception, construction et essais —
Partie 4: Bouteilles à gaz composites entièrement bobinées renforcées par des fibres et tubes d'une contenance allant jusqu'à 150 l avec liners métalliques transmettant la charge

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

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*

— *Part 4: Fully wrapped fibre reinforced composite gas cylinders up to 150 l with load-sharing welded metallic liners*

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 worldwide usage. The objective is to balance design and economic efficiency against international acceptance and universal utility.

This part of ISO 11119 aims to eliminate the concern about climate, duplicate inspection, and restrictions currently existing because of a lack of definitive International Standards and is not to be construed as reflecting on the suitability of the practice of any nation or region.

It is possible that some procedures and tests will require precautions to be taken for the health and/or safety of the operator(s). Safety, health, and environmental concerns are not addressed and is to be addressed by those who wish to implement this International Standard.

This part of ISO 11119 is intended to be used under a variety of national and international regulatory regimes. Where there is any conflict between this part of ISO 11119 and any applicable regulation, the regulation always takes precedence.

This part of ISO 11119 has been written so that it is suitable to be referenced in the UN Model Regulations.[1]

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

Annex C of this part of ISO 11119 is normative.

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

Part 4: Fully wrapped fibre reinforced composite gas cylinders up to 150 l with load-sharing welded metallic liners

1 Scope

This part of ISO 11119 specifies requirements for composite gas cylinders with load-sharing welded liners between 0,5 l and 150 l water capacity and a maximum test pressure of 450 bar for the storage and conveyance of compressed or liquefied gases.

NOTE 1 1 bar = 10^5Pa = 10^5N/m^2.

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

The cylinders in this part of ISO 11119 are type 3 fully wrapped cylinders with a load-sharing metal liner and composite reinforcement on both the cylindrical portion and the dome ends.

Cylinders produced in accordance with this part of ISO 11119 have a minimum design life of 15 years. Cylinders with test pressure of 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, ISO 11119-2 applies.

NOTE 2 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 3341, *Textile glass — Yarns — Determination of breaking force and breaking elongation*

ISO 4706:2008, *Gas cylinders — Refillable welded steel cylinders — Test pressure 60 bar and below*

ISO 5817:2014, *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*

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

ISO 10042:2005, *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 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*

ISO 13919-1:1996, *Welding — Electron and laser-beam welded joints — Guidance on quality levels for imperfections — Part 1: Steel*

ISO 13919-2:2001, *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 18172-2:2007, *Gas cylinders — Refillable welded stainless steel cylinders — Part 2: Test pressure greater than 6 MPa*

ISO 20703:2006, *Gas cylinders — Refillable welded aluminium-alloy cylinders — Design, construction and testing*

ASTM D2290-12,*Standard test method for apparent hoop tensile strength of plastic or reinforced plastic pipe*

ASTM D2291-09, *Standard practice for fabrication of ring test specimens for glass-resin composites*

ASTM D2343-09, *Standard test method for tensile properties of glass fiber strands, yarns, and rovings used in reinforced plastics*

ASTM D2344/D2344M-13, *Standard test method for short-beam strength of polymer matrix composite materials and their laminates*

ASTM D4018-11, *Standard test methods for properties of continuous filament carbon and graphite fiber tows*

EN 14638-3:2010, *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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
fibre
continuous filaments laid up in tow form

3.2
autofrettage
pressure application procedure that 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 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 welding procedure, and design from the same material cast and heat treated (if applicable) at the same temperature and for the same period of time

3.4
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

3.5
burst pressure
highest pressure reached in a cylinder, p_b, or liner, p_{bl}, during a burst test

3.6
calculated liner proof pressure
pressure derived from the test pressure of the relevant liner design standard

Note 1 to entry: The liner design standards are given in Table 1. The calculated liner proof pressure is used for the liner integrity test.

3.7
composite overwrap
combination of fibres and matrix

3.8
dedicated gas service
service in which a cylinder is to be used only with a specified gas or group of gases

3.9
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

3.10
equivalent liner
liner that is manufactured from the same nominal raw materials, using the same process(es) of manufacture and having the same physical structure and the same nominal physical properties as in an approved cylinder design

3.11
exterior coating
layers of material applied to the cylinder as protection or for cosmetic purposes

Note 1 to entry: The coating can be clear or pigmented.

3.12
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

3.13
load-sharing liner
liner that has a burst pressure greater than or equal to 5 % of the nominal burst pressure of the finished composite cylinder

3.14
thermoplastic material
plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.15
thermosetting material
plastics that hardens permanently into a substantially infusible and insoluble product when cured by the application of heat or chemical means

3.16
working pressure
settled pressure of a compressed gas at a reference temperature of 15 °C in a full gas cylinder

3.17
nominal outside diameter
diameter of the cylinder specified by the manufacturer for the type approval including tolerances

EXAMPLE Tolerances could be ±1 %.

3.18
type 3 cylinder
fully wrapped cylinder with a load-sharing metal liner and composite reinforcement on both cylindrical and dome ends

3.19
test pressure
p_h
required pressure applied during the pressure test of the composite cylinder

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
P_{bl}	burst pressure of the liner	bar
P_l	calculated liner proof pressure for liner integrity test	bar
N	number of cycles with pressurization to test pressure	units
N_d	number of cycles with a pressurization to maximum developed pressure	units
Y	number of years of design life	units
B	width of weld reinforcement	mm
h	height or width of imperfection	mm
t	wall or plate thickness (nominal size)	mm

5 Inspection and testing

Evaluation of conformity shall be carried out in accordance with the applicable regulations of the countries of use.

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.

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 requirements are given in Table 1.

Table 1 — Liner requirements

Type of liner	Liner material	Liner heat treatment	Applicable standard	Relevant sections of the applicable standard
Welded steel liner	Carbon steel	Yes	ISO 4706:2008	5, 6.3, 8, 9
		No	EN 14638-3:2010	4, 5.4, 6, 8
	Stainless steel	As defined in the standard	ISO 18172-2:2007	4, 5.6, 6, 8
Welded aluminium Alloy liner	Aluminium alloy	As defined in the standard	ISO 20703:2006	4, 5.4, 6, 7

Design requirements are excluded as these are specified by the manufacturer for the design of the composite cylinder (7.2.4).

6.1.2 The composite cylinder manufacturer shall verify that each new batch of materials has the correct properties and is of satisfactory quality and records shall be maintained 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 filament material and the matrix system component materials shall be accompanied with sufficient documentation to be able to fully identify the batch of materials used in the manufacture of each cylinder.

6.2.4 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 conformity from the material manufacturer is considered acceptable for the purposes of verification.

6.2.5 Batches of materials shall be identified and documented.

7 Design and manufacture

7.1 General

7.1.1 A type 3 fully wrapped composite gas cylinder with load-sharing welded liner shall comprise of the following:

a) an internal metal liner which carries part of the longitudinal and circumferential load. For cylinders with test pressure above 60 bar, the maximum permissible load share by the liner shall be 30 %, which results in a maximum liner burst pressure of 30 % of minimum burst pressure of the finished cylinder;

b) a composite overwrap formed by layers of continuous fibres in a matrix;

c) an optional external protection system.

There shall be no adverse reaction or interaction (e.g. epoxy coating with epoxy matrix) between the liner and the reinforcing fibre by the application of a suitable protective coating to the liner prior to the wrapping process.

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. Construction and workmanship requirements shall be in accordance with those in the standards listed in Table 1. If the cylinder includes permanently attached components (e.g. neck rings), they shall be considered as an integral part of the cylinder and form part of the qualified design.

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

7.1.2 Cylinders with a test pressure less than 60 bar shall have a non-limited design life

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 specified 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) the following:

a) the material, including limits of chemical analysis;

b) the dimensions, minimum wall thickness, straightness, and out-of-roundness with tolerances;

c) the process and specification of manufacture;

d) the weld profile including the manufacturing procedure, dimensions and tolerances, and the maximum limits for excess weld metal as specified in 7.3.1 a);

e) the heat treatment, temperatures, duration, and tolerances, if applicable;

f) the inspection procedures (in addition to those specified on the referred liner standard in accordance with Table 1);

g) the material properties including minimum mechanical properties and hardness ranges, where applicable;

h) the calculated proof pressure of the liner for liner integrity test, P_l (in accordance with 8.5.4);

i) the minimum design burst pressure, P_{bl};

j) the 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) the following:

a) the fibre material, specification, and mechanical properties requirements (the mechanical properties shall be as specified by the manufacturer);

b) the minimum composite thickness;

c) the thermosetting matrix – specifications (including resin, curing agent, and accelerator) and resin bath temperature where applicable;

d) the thermoplastic matrix system – main component materials, specifications, and process temperatures;

e) the overwrap construction including the number of strands used, number of layers, and layer orientation and tensioning of the fibre at wrapping; this tension can be either a process tension to aid the wrapping process or the much higher pre-tensioning to actively change the final stresses in the finished cylinder;

f) the curing process, temperatures, duration, and tolerances, where applicable.

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

a) the nominal water capacity in litres at ambient conditions;

b) the dimensions with tolerances;

c) the list of intended contents if intended for dedicated gas service;

d) the test pressure, P_h;

e) the working pressure, P_w (if applicable), that shall not exceed 2/3 × P_h test pressure;

f) the maximum developed pressure at 65 °C for specific dedicated gas(es), P_{max};

g) the minimum design burst pressure, P_b;

h) the design life in years;

i) the autofrettage pressure and approximate duration or details of the fibre tensioning, if applicable;

j) the nominal mass of the finished composite cylinder, including tolerances;

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

l) the additional test requirements for special applications.

7.3 Manufacturing

7.3.1 The liner shall be manufactured in accordance with the manufacturer's design (see 7.2.2) and standard for the relevant liner requirements (as specified in 6.1.1).

a) The weld profile shall not exceed the dimensions and tolerances and the maximum limits for excess weld metal as specified in Table 2.