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ISO/DIS 11119-3

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

Part 3:
Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners or without liners

Bouteilles à gaz — Bouteilles à gaz rechargeables en matériau composite et tubes — Conception, construction et essais —

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 ou sans liners

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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 standard has been written so that it is suitable to be referenced in the UN Model Regulations[1]. This edition cancels and replaces ISO 11119-3:2012.

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 or without liners*

— *Part 4: Fully wrapped fibre reinforced composite gas cylinders with load-sharing welded metal liners*

Note [1] United Nations. *Recommendations on the Transport of Dangerous Goods – Model Regulations.*

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 — Design, construction and testing —

Part 3:
Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners or without liners

1 Scope

This part of ISO 11119 **specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes, examination and testing at time of manufacture for**

— type 4 composite fully wrapped cylinders or tubes with a non-load sharing liner and composite reinforcement on both the cylindrical portion and the dome ends

— type 5 fully wrapped cylinders or tubes without liners and with a test pressure of less than 60 bar and composite reinforcement on both the cylindrical portion and the dome ends (Type 5 linerless cylinders and tubes made from two or more parts joined together are not permitted under this standard).

— water capacities up to 450 l

— for the storage and conveyance of compressed or liquefied gases

— cylinders and tubes with composite reinforcement of carbon fibre, aramid fibre or glass fibre (or a mixture thereof) within a matrix

— a minimum design life of 15 years.

Cylinders and tubes manufactured and tested to this standard are not intended to contain toxic, oxidizing or corrosive gases.

This standard 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*

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

ISO 7225, *Gas cylinders — Precautionary labels*

ISO 10286, *Gas cylinders – Terminology*

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*

EN 12165, *Copper and copper alloys. Wrought and unwrought forging stock*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 10286 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

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

3.2
batch
set of homogeneous items or material

Note 1 to entry: 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 from the same material family and similar properties to a fibre 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
equivalent matrix
resin matrix from the same chemical family and similar properties to the resin matrix used in a previously prototype tested cylinder

3.13
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.

3.14
glass fibre
continuous filaments of glass laid up in tow form

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 that is used to bind and hold the fibres in place

3.17
non-load-sharing liner
liner that has a burst pressure less than 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
nominal outside diameter
diameter of the cylinder specified by the manufacturer for the type approval including tolerances (e.g. +/- 1 %)

3.21
Type 4 cylinder
fully wrapped cylinder with a non-load sharing liner and composite reinforcement on both the cylindrical portion and the dome ends

3.22
Type 5 cylinder
fully wrapped cylinder without a liner and with composite reinforcement on both the cylindrical portion and dome ends

3.23
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 boss assembly) shall be manufactured from materials suitable for the gas to be contained as specified in ISO 11114-1 and ISO 11114-2 where applicable. Materials used to manufacture the components of boss assemblies attached to non-metallic liners shall fulfil the material performance requirements of this document.

6.1.2 The metallic liner or metallic boss component materials shall conform to the following material performance tests in the appropriate standard:

a) seamless steel liners or bosses: the material tests in ISO 9809-1, ISO 9809-2 or ISO 9809-3;

b) seamless stainless steel liners or bosses: the material tests in ISO 9809-4;

c) seamless aluminium alloy liners or boss components: Sustained load cracking test and stress corrosion cracking test (if size permits sample extraction) in line with ISO 7866**.**

d) Brass boss components: material composition as defined in EN 12165.

Testing carried out on material sample coupons is acceptable for metallic boss components; where coupons are to be used, the coupons shall be produced from a representative sample of raw material. (i.e. if a component is manufactured from bar stock, the coupon shall be manufactured from bar stock).

6.1.3 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.

6.1.4 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, local environmental conditions and to the intended life of the product.

6.2.3 The suppliers of the filament material and the matrix component materials 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:

— 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 and

— 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 without liner with a test pressure of less than 60 bar shall comprise of:

— 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 and

— an optional external protection system.

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 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 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 — 3,6

— for aramid — 3.15

— for carbon — 3.0

The fibre stress ratio for Type 4 and Type 5 cylinders can be confirmed by burst testing. The strength of the individual types of fibres used in hybrid construction may be verified by testing of containers reinforced with a single type of fibre. In a hybrid construction, the applicable stress ratio requirements shall be met in one of the two following ways:

a) if load sharing between the various fibre reinforcing materials is considered a fundamental part of the design, each fibre shall meet the stated stress ratio requirements.

b) if load sharing between fibres is not considered as a fundamental part of the design, then one of the reinforcing fibres shall be capable of meeting the stress ratio requirements even if all other fibre reinforcing materials are removed.

7.1.5 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, curing agent, accelerator, materials and specifications where applicable;

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;