BS EN 14427:2014

BSI Standards Publication

LPG equipment and accessories — Transportable refillable fully wrapped composite cylinders for LPG — Design and construction

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National foreword

This British Standard is the UK implementation of EN 14427:2014. It supersedes BS EN 14427:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PVE/19, LPG containers and their associated fittings.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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LPG equipment and accessories - Transportable refillable fully wrapped composite cylinders for LPG - Design and construction

Équipements pour gaz de pétrole liquéfiés et leurs accessoires - Bouteilles en matériau composite, transportables et rechargeables, pour gaz de pétrole liquéfiés (GPL) - Conception et fabrication

Flüssiggas-Geräte und Ausrüstungsteile - Ortsbewegliche wiederbefüllbare vollumwickelte Flaschen aus Verbundwerkstoff für Flüssiggas (LPG) - Auslegung und Bau

This European Standard was approved by CEN on 4 January 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Page

Foreword

This document (EN 14427:2014) has been prepared by Technical Committee CEN/TC 286 “Liquefied petroleum gas equipment and accessories”, the secretariat of which is held by NSAI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2014 and conflicting national standards shall be withdrawn at the latest by December 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14427:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This standard has been submitted for reference into the RID and ADR (see [11] and [12]).

Environmental considerations recorded in Annex C.

The main technical changes to this revision include a full revision of the manufacturing processes in line with advances in manufacturing processes.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard calls for the use of substances and procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the drafting of this European Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

It is recommended that manufacturers develop an environmental management policy. For guidance see ISO 14000 series.

All pressures are gauge unless otherwise stated.

NOTE This standard requires measurement of material properties, dimensions and pressures. All such measurements are subject to a degree of uncertainty due to tolerances in measuring equipment, etc. It may be beneficial to refer to the leaflet “Measurement uncertainty leaflet SP INFO 2000 27” [14].

1 Scope

This European Standard

— specifies minimum requirements for materials, design, construction, prototype testing and routine manufacturing inspections of fully wrapped composite cylinders with a water capacity from 0,5 litre up to and including 150 litres for liquefied petroleum gases (LPG) exposed to ambient temperatures, with a test pressure of at least 30 bar;

— is only applicable to cylinders which are fitted with a pressure relief valve (see 4.1.3);

— is applicable to cylinders with a liner of metallic material (welded or seamless) or non-metallic material (or a mixture thereof), reinforced by fibres of glass, carbon or aramid (or a mixture thereof);

— is also applicable to composite cylinders without liners.

Cylinders manufactured to this European Standard are suitable for temperatures down to −40 °C.

This European Standard does not address the design, fitting and performance of removable protective sleeves. Where these are fitted, the choice of material and sleeve performance should be considered separately.

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.

EN 1439, *LPG equipment and accessories - Procedure for checking LPG cylinders before, during and after filling*

EN 1442, *LPG equipment and accessories - Transportable refillable welded steel cylinders for LPG - Design and construction*

EN 1964-3, *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 Rm value of less than 1100 MPa*

EN 12807, *LPG equipment and accessories - Transportable refillable brazed steel cylinders for liquefied petroleum gas (LPG) - Design and construction*

EN 13110, *LPG equipment and accessories - Transportable refillable welded aluminium cylinders for liquefied petroleum gas (LPG) - Design and construction*

EN 14140, *LPG equipment and accessories - Transportable refillable welded steel cylinders for LPG - Alternative design and construction*

EN 14717, *Welding and allied processes - Environmental check list*

EN 14894, *LPG equipment and accessories - Cylinder and drum marking*

EN ISO 75-1, *Plastics - Determination of temperature of deflection under load - Part 1: General test method (ISO 75-1)*

EN ISO 75-3, *Plastics - Determination of temperature of deflection under load - Part 3: High-strength thermosetting laminates (ISO 75-3)*

EN ISO 175, *Plastics - Methods of test for the determination of the effects of immersion in liquid chemicals (ISO 175)*

EN ISO 527-1, *Plastics - Determination of tensile properties - Part 1: General principles (ISO 527-1)*

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

EN ISO 1133 (all parts), *Plastics - Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics (ISO 1133)*

EN ISO 1183-1, *Plastics - Methods for determining the density of non-cellular plastics - Part 1: Immersion method, liquid pyknometer method and titration method (ISO 1183-1)*

EN ISO 1183-2, *Plastics - Methods for determining the density of non-cellular plastics - Part 2: Density gradient column method (ISO 1183-2)*

EN ISO 1183-3, *Plastics - Methods for determining the density of non-cellular plastics - Part 3: Gas pyknometer method (ISO 1183-3)*

EN ISO 1628-3, *Plastics - Determination of the viscosity of polymers in dilute solution using capillary viscometers - Part 3: Polyethylenes and polypropylenes (ISO 1628-3)*

EN ISO 2555, *Plastics - Resins in the liquid state or as emulsions or dispersions - Determination of apparent viscosity by the Brookfield Test method (ISO 2555)*

EN ISO 2884-1, *Paints and varnishes - Determination of viscosity using rotary viscometers - Part 1: Cone-and-plate viscometer operated at a high rate of shear (ISO 2884-1)*

EN ISO 3146, *Plastics - Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods (ISO 3146)*

EN ISO 3231, *Paints and varnishes - Determination of resistance to humid atmospheres containing sulfur dioxide (ISO 3231)*

EN ISO 7866, *Gas cylinders - Refillable seamless aluminium alloy gas cylinders - Design, construction and testing (ISO 7866)*

EN ISO 9227, *Corrosion tests in artificial atmospheres - Salt spray tests (ISO 9227)*

EN ISO 9809-1, *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 9809-1)*

EN ISO 9809-2, *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 9809-2)*

EN ISO 9809-3, *Gas cylinders - Refillable seamless steel gas cylinders - Design, construction and testing - Part 3: Normalized steel cylinders (ISO 9809-3)*

EN ISO 10286, *Gas cylinders - Terminology (ISO 10286)*

EN ISO 11114-2, *Gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 2: Non-metallic materials (ISO 11114-2)*

EN ISO 14245, *Gas cylinders - Specifications and testing of LPG cylinder valves - Self-closing (ISO 14245)*

EN ISO 15995, *Gas cylinders - Specifications and testing of LPG cylinder valves - Manually operated (ISO 15995)*

EN ISO 15512, *Plastics - Determination of water content (ISO 15512)*

EN ISO 16474-3:2013, *Paints and varnishes - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps (ISO 16474-3:2013)*

ISO 3341, *Textile glass - Yarns - Determination of breaking force and breaking elongation*

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

ISO 11357-3, *Plastics - Differential scanning calorimetry (DSC) - Part 3: Determination of temperature and enthalpy of melting and crystallization*

ASTM D 2196-10, *Test methods for rheological properties of non-newtonian materials by rotational (Brookfield type) viscometer*

ASTM D 2290-08, *Test method for apparent hoop tensile strength of plastics and reinforced plastic by split disk method*

ASTM D 2291-09, *Standard practice for fabrication of ring test specimens for glass-resin composites*

ASTM D 2343-09, *Standard test method for tensile properties of glass fibre strands, yarns and rovings used in reinforced plastics*

ASTM D 2344-00, *Standard test method for short-beam strength of polymer matrix composite materials and their laminates*

ASTM D 3418-08, *Standard test method for transition temperatures and enthalpies of fusion and crystallization of polymers by differential scanning calorimetry*

ASTM D 4018-99, *Standard test methods for tensile properties of continuous filament carbon and graphite fibre tows*

3 Terms and definitions

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

3.1
liquefied petroleum gas
LPG
low pressure liquefied gas composed of one or more light hydrocarbons which are assigned to UN 1011, UN 1075, UN 1965, UN 1969 or UN 1978 only and which consists mainly of propane, propene, butane, butane isomers, butene with traces of other hydrocarbon gases

3.2
ambient test temperature
temperature of surroundings varying between 10 °C and 35 °C (for test purposes only)

3.3
autofrettage
pressure application procedure which strains the metal liner past its yield point sufficiently 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

3.4
batch
<fibres> pre-impregnated fibres or components of the resin system homogeneous quantity of material, identified and certified as such by the supplier

3.5
batch
<metallic liners> quantity of liners of the same nominal diameter, thickness, length and design, made successively from the same material cast and subjected to the same heat treatment for the same length of time

3.6
batch
<non-metallic liners> quantity of liners of the same nominal diameter, thickness, length and design, made successively from the same batch of materials and subjected to the same manufacturing process

3.7
batch
<finished cylinders with liners> quantity of up to 200 finished cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design

Note 1 to entry: The batch may contain different batches of liners, providing the batches are nominally the same and have had the same treatment, fibres and matrix materials.

3.8
batch
<finished cylinders with no liners> quantity of up to 200 finished cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design

3.9
burst pressure
highest pressure reached in a cylinder or liner during the relevant burst test

3.10
composite overwrap
fibres, or fibres embedded in a matrix taken together as a combined unit

3.11
elastomeric material
material which at ambient temperature can be stretched repeatedly to at least twice its original length and will return with force to approximately its original length immediately upon release of the stress

3.12
exterior coating
layer of clear or pigmented material applied to the cylinder as protection

3.13
fibre
strand
load-carrying part of the composite overwrap e.g. glass, aramid or carbon

3.14
fully wrapped composite cylinder
cylinder reinforced by wrapping to take both circumferential and longitudinal stress

3.15
liner
metallic or non-metallic vessel that retains the LPG in the cylinder, but may also contribute to the mechanical behaviour of the cylinder

Note 1 to entry: This is a load sharing liner

3.16
non-load sharing liner
liner that contributes less than 5 % of the load bearing of the overall cylinder design at test pressure, and is intended only to prevent diffusion of LPG

3.17
non-metallic liner
liner made from thermoplastic, thermosetting, or elastomer material

3.18
matrix
material which is used to bind and hold the fibres in place

3.19
thermoplastic
plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.20
thermoset
plastics which when cured by the application of heat or chemical means changes into a substantially infusible and insoluble product

3.21
removable protective sleeve
external sleeve intended to provide protection to the cylinder during operation which is not an integral part of the design, not permanently fixed to the cylinder but which can be removed during service without destroying the sleeve without the use of special tools

4 Design and manufacture

4.1 General

4.1.1 Fully wrapped composite LPG cylinders may be manufactured with a metallic or non-metallic liner or without a liner. Cylinder bodies without a liner may be manufactured from two parts joined together with adhesive.

The thicknesses of the cylinder, including any liner, shall be determined by satisfactory completion of the performance tests described in Clause 5. No design calculations are required.

The cylinder may also include an external coating and/or additional parts such as valve shrouds/handles, bases and cages. Where these are an integral part of the design, they shall be permanently fixed to the cylinder such that they cannot be removed during service without destroying them, or by use of special tools.

The design of the cylinder shall take the following into account:

— minimizing the use of materials;

— the fittings required for the cylinder;

— minimizing the environmental impact of in service maintenance and end of life disposal;

— efficient transport of finished product.

For the welding associated with metallic liners, the environmental impact of welding and allied processes shall be assessed in accordance with EN 14717.

The manufacturer should endeavour to minimize wastage of material by selecting appropriately sized materials related to the finished parts required for manufacture. Unavoidable waste/scrap material should be recycled where possible.

Noise levels and harmful emissions from the production process should be evaluated and measures put into place to minimize the impact upon the external environment.

4.1.2 The location of all openings for service connections shall be restricted to one end of the cylinder.

Where it is necessary, for production reasons, to have an opening in both ends, the non-service opening shall be permanently sealed before completion of the cylinder. The sealing arrangement shall be:

— permanent;

— inaccessible to users of the cylinder in service; and

— designed so that any leakage of product past the seal can only be released local to the service valve(s) so that it will be detectable during post-fill leak checks.

4.1.3 Due to the lack of volumetric expansion, cylinders designed to this European Standard are intended to be used only when fitted with a pressure relief valve (see EN 13953).

4.2 Liner

4.2.1 Metallic liners

4.2.1.1 Metallic liners shall be manufactured in accordance with the relevant clauses of the following European Standards:

a) seamless steel liners: EN ISO 9809-1, EN ISO 9809-2 or EN ISO 9809-3, as appropriate;

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

c) seamless aluminium alloy liners: EN ISO 7866;

d) welded steel liners: EN 1442 or EN 14140;

e) brazed steel liners: EN 12807;

f) welded aluminium liners: EN 13110.

4.2.1.2 The relevant clauses are those covering: materials, thermal treatments, neck design, construction and workmanship, mechanical tests.

NOTE This excludes the design requirements, since the design is determined by the manufacturer in accordance with this European Standard for the design of the composite cylinder.

4.2.2 Non-metallic liners

4.2.2.1 A cylinder with a non-metallic liner shall be designed as if the liner will be non-load sharing. The liner material shall be compatible with LPG as determined by EN ISO 11114-2.

4.2.2.2 Where a metal end boss is used in a non-metallic liner, it shall be considered part of the liner material and shall fulfil the material requirements specified in the relevant standard listed in 4.2.1.1.

4.2.3 Design drawing

4.2.3.1 A fully dimensioned drawing of the liner shall be produced which shall include the specification of the material and material properties.

4.2.3.2 The following properties shall be specified for metallic liners:

— minimum yield stress;

— minimum tensile strength;

— minimum elongation; and

— minimum burst pressure;

4.2.3.3 The following properties shall be specified for non-metallic liners:

— density;

— for thermoplastics, the melting point, as determined by EN ISO 3146 or ISO 11357;

— for thermoset materials, the temperature of deflection under load, as determined by EN ISO 75-1 and EN ISO 75-3;

— for thermoset materials, the glass transition temperature as determined by differential scanning calorimetry;

— composition;

— compatibility with LPG as determined by EN ISO 11114-2; and

— end boss material specification.

NOTE The end boss specifications includes:

— minimum yield stress;

— minimum tensile strength;

— minimum elongation of the boss material.

4.3 Composite overwrap

4.3.1 Materials

Material requirements for the fibre and the matrix, where applicable, shall be as specified by the manufacturer.

4.3.2 Winding

4.3.2.1 Procedures shall be defined for the winding and curing process to ensure good repeatability and traceability.

4.3.2.2 For all cylinders, the following parameters shall be defined and monitored:

a) the batch numbers of the fibres used;

b) the number of strands used;

c) the winding tension per strand, (if applicable);

d) the winding speed(s);

e) the winding angle and/or pitch for each layer; and

f) the number and order of layers.

4.3.2.3 Where a matrix system is used, the following additional parameters shall be defined and monitored:

a) percentages of the components of the matrix system and their batch numbers;

b) resin bath temperature range, (where applicable);

c) the procedure used to obtain correct impregnation (e.g. wet winding or pre-impregnation);

d) the polymerisation cycle; and

e) the polymerisation process (e.g. thermal cycling, ultrasonic, ultraviolet, or radiation).

4.3.2.4 For thermal polymerisation, the temperature and the length of the polymerisation cycle of the resin system shall be such that they do not adversely affect the mechanical characteristics of the liner. In addition, tolerances for holding time and temperature at each stage shall be defined.

4.3.3 Cylinders without liners comprising two parts

For cylinders without liners which comprise two parts joined with adhesive, additional procedures and parameters shall be defined, monitored and recorded for the adhesive system as follows:

a) percentages of the components and their batch numbers;

b) polymerisation cycle; and

c) polymerisation process (e.g. thermal cycling, ultrasonic, ultraviolet, or radiation).

4.4 Finished cylinder

4.4.1 Design drawings

4.4.1.1 A fully dimensioned drawing of all parts that constitute the finished cylinder shall be produced. The design drawing shall also include tolerances on all dimensions, including out-of-roundness and straightness.

4.4.1.2 The drawing shall include the specification of the material(s), the material properties and the reinforcement pattern. The specifications and the reinforcement patterns may be given in a technical specification referenced on the drawing.

4.4.1.3 The details of any exterior coating and additional, permanently fixed parts, which are an integral part of the design, shall be specified.

4.4.1.4 The manufacturer shall specify the minimum burst pressure for the design which shall be at least 67,5 bar (the test pressure shall be at least 30 bar) i.e. a burst ratio of 2,25.

4.4.1.5 The drawing shall specify any special characteristics or special limitations (e.g. maximum fitting torque restrictions, the requirements for fitting a relief valve).

4.4.2 Cylinders without liner

4.4.2.1 The composition of the composite materials and their properties shall be specified, as follows:

a) tensile strength;

b) tensile modulus;

c) elongation;

d) heat distortion temperature;

e) viscosity.

4.4.2.2 The composite materials shall be compatible with LPG as determined by EN ISO 11114-2.

4.4.2.3 Where a metal end boss is used in a cylinder without a liner the drawing of the cylinder shall include the specification of the material and material properties of the boss in accordance with 4.2.3.

4.4.3 Autofrettage

4.4.3.1 Internal pressurization to autofrettage pressure of cylinders with metallic liners can be part of the manufacturing process; if so, this operation shall be executed after polymerisation of the composite for thermosetting resins or after the consolidation process for thermoplastics.

4.4.3.2 During the autofrettage operation, the following parameters shall be recorded:

a) autofrettage pressure;

b) duration of application of this pressure;

c) expansion at autofrettage pressure;

d) permanent expansion after autofrettage.

4.4.3.3 Where autofrettage is performed, a check shall be made that the procedure has been effectively performed on all cylinders.

4.4.4 Manufacturing requirements for the finished cylinder

The internal and external surfaces of the finished cylinder shall be free of defects which could adversely affect the safe working of the cylinder. In addition there shall be no visible foreign matter present inside the cylinder (e.g. resin, swarf or other debris).

4.4.5 Neck ring

Where a neck ring is provided, it shall be of a material compatible with that of the cylinder. It shall be securely attached by a method appropriate to the cylinder or boss material so as to withstand the test specified in Test No. 18 (see 5.2.18).

4.4.6 Cylinder stability

For cylinders designed to stand on their base, the variation from vertical shall be less than 1 % of their height. The outer diameter of the surface in contact with the ground shall be greater than 75 % of the nominal outside diameter.

Due consideration should be given to the safe handling (by mechanical or manual means) in relation to the size and mass of the cylinder, e.g. handles or lifting points.

5 Cylinder and material tests

5.1 General

This clause describes the tests to be conducted on fully wrapped composite cylinders, cylinder liners and the materials used in manufacture of cylinders, as required by Annex A, for:

— prototype testing of new cylinder designs (see A.2);

— design variant testing (see A.3); and

— production testing (see A.4).

NOTE In RID/ADR “production tests” are referred to as “initial inspection and tests”.

The tests listed are mandatory or optional, as identified in the schedule of testing and inspections in Annex A.

Cylinders subjected to the tests shall include all permanently fixed parts, unless otherwise specified.

No tests shall be performed with a removable protective sleeve fitted to the cylinder, except where specified (see Test 10, 5.2.10.1).

Attention is drawn to the risks associated with testing pressurized cylinders. Appropriate safety precautions should be taken in order to reduce the risks to testing personnel e.g. during positioning and handling of cylinders they can be depressurised between individual tests.

Reference should also be made to EN 1439, which requires the cylinder manufacturer to perform additional tests to determine the rejection limits for in-service damage and to include these limits in the documentation for the cylinder.

Consideration should be given to minimising the environmental impact of the tests specified by including the possible recovery of test fluids, recycling of mechanical test specimens, safe disposal of chemicals and destroyed cylinders, etc.

5.2 Test procedures and test requirements

5.2.1 Test No. 1 – Composite material tests, including adhesives (where applicable)

5.2.1.1 Tests on all cylinders

5.2.1.1.1 Procedure

Tests on the composite materials to establish their mechanical properties shall be carried out as follows for:

a) Tensile properties of fibres in accordance with the following standards:

For glass, aramid:

— ISO 8521 or ASTM D 2290-08 and ASTM D 2291-09

— ISO 3341 or ASTM D 2343-09

For carbon:

— ASTM D 3418-08

— ASTM D 4018-99

b) Shear properties for thermosetting plastics in accordance with the following standard:

— ASTM D 2344-00

c) Matrix properties in accordance with the following standards:

— glass transition temperature: ASTM D 3418-08

— heat distortion temperature: EN ISO 75-3

— viscosity: ASTM D 2196-10

NOTE For tests specified above at a, b, and c, alternative standards are acceptable providing that they give equivalent results.

d) Test temperature

Material tests specified in a) b) and c) above shall be carried out at ambient test temperature and at –20 °C (with a tolerance of +0°C / −5°C) can be carried out.

At each temperature, three specimens shall be tested.

As an alternative, the cylinder impact tests (Test No. 9, see 5.2.9) with the cylinders at –20 °C (with a tolerance of +0°C / −5°C) can be carried out.

Where possible after completing of the tests all material should be processed for recycling.

5.2.1.1.2 Criteria

The mechanical properties shall meet the minimum requirements for the design as specified by the manufacturer.

The average of the test results at –20 °C shall not be less than 95 % of the average value obtained at room temperature.

5.2.1.2 Additional tests on cylinders without liners

5.2.1.2.1 Procedure

Additional tests on the composite materials and adhesives (where applicable) shall be carried out using the following standards for:

Tensile strength	- EN ISO 527-1 and EN ISO 527-2;
Tensile modulus	- EN ISO 527-1 and EN ISO 527-2;
Elongation	- EN ISO 527-1 and EN ISO 527-2;
Heat distortion temperature	- EN ISO 3146 or ISO 11357 for thermoplastics and EN ISO 75-1 and EN ISO 75-3 for thermoset materials;
Viscosity	- EN ISO 1628-3 for thermoplastics and EN ISO 2884-1 or EN ISO 2555 and ASTM D 2196–10 for thermosets;
Composition	- Test specification as specified by the manufacturer.

Alternative standards are acceptable providing that they give equivalent results.

Where possible after completing of the tests all material should be processed for recycling.

5.2.1.2.2 Criteria

The mechanical properties shall meet the minimum requirements for the design as specified by the manufacturer.

5.2.2 Test No. 2 – Liner material tests

5.2.2.1 Procedure

5.2.2.1.1 Metallic liner

Tests on the metallic liner material shall be carried out, following the test procedures of the appropriate standards as follows:

a)	Seamless steel	- as described in EN ISO 9809-1, EN ISO 9809-2 or EN ISO 9809-3, as appropriate;
b)	Seamless stainless steel	- as described in EN 1964-3;
c)	Welded stainless steel	- as described in EN 14140;
d)	Seamless aluminium	- as described in EN ISO 7866;
e)	Welded steel	- as described in EN 1442 or EN 14140;
f)	Welded aluminium	- as described in EN 13110;
g)	Brazed steel	- as described in EN 12807.

Where possible after completing of the tests all material should be processed for recycling.

5.2.2.1.2 Non-metallic liner

Tests on the non-metallic liner material shall be carried out, following the test procedures of the appropriate standards as follows:

a) Thermoplastic materials:

Viscosity	- EN ISO 1628-3;
Melting point	- EN ISO 3146 or ISO 11357;
Water content	- EN ISO 15512;
Density	- EN ISO 1183-1, EN ISO 1183-2 or EN ISO 1183-3;
Melting flow index	- EN ISO 1133;
Chemical resistance	- EN ISO 175.

b) Thermoset and elastomeric materials:

Viscosity	- EN ISO 2884-1 or ASTM D 2196-10;
Elongation at break	- EN ISO 527-1 and EN ISO 527-2;
Tensile strength	- EN ISO 527-1 and EN ISO 527-2;
Density	- EN ISO 1183-1, EN ISO 1183-2 or EN ISO 1183-3;
Chemical resistance	- EN ISO 175;
Glass transition temperature	- By differential scanning calorimetry.

Alternative standards are acceptable providing that they give equivalent results.

Where possible after completing of the tests all material should be processed for recycling.

5.2.2.2 Criteria

The mechanical properties shall meet the minimum requirements for the design as specified by the manufacturer.

5.2.3 Test No. 3 – Liner burst test

5.2.3.1 Procedure

The hydraulic burst test shall be carried out using a test rig, which allows pressure to be increased at a controlled rate.

The test shall be carried out at ambient test temperature and the temperature on the external surface of the liner shall be maintained at less than 50 °C. The rate of pressurization shall not exceed 10 bar per second and the duration of the test shall be at least 40 s.

The cylinder shall be pressurized at a controlled rate until failure. The pressure against time curve or pressure against volume curve shall be plotted.

The maximum pressure achieved during the test shall be recorded as the burst pressure.

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

5.2.3.2 Criteria

The burst pressure of the liner shall be equal to or greater than the minimum design burst pressure, as specified on the drawing required by 4.2.3.

The liner shall remain in one piece.

5.2.3.3 Parameters to monitor and record

The following shall be monitored and recorded:

— burst pressure;

— the number of pieces after the test;

— a description of failure; i.e. brittle fracture, ductile fracture, etc.; and

— the pressure/time curve or pressure/volume curve.

5.2.4 Test No. 4 – Hydraulic proof test of finished cylinders

5.2.4.1 General

Where cylinders are subjected to autofrettage, the hydraulic proof pressure test may immediately follow or be part of the autofrettage operation.

The test fluid shall be a non-corrosive liquid.

NOTE Subject to competent authority approval, a non-corrosive gas can be used provided that appropriate safety precautions are taken.

Where possible after completing of the tests all material should be processed for recycling

The test fluid should be processed for recycling

5.2.4.2 Procedure

The test shall be carried out at ambient test temperature.

The pressure in the cylinder shall be increased at a controlled rate until at least 30 bar is reached. The cylinder shall remain at this pressure for at least 30 s.

The tolerance of the applied test pressure shall be between –0 % to +3 %.

5.2.4.3 Criteria

The pressure shall remain steady.

There shall be no leaks.

After the test, the cylinder shall show no visible permanent deformation.

5.2.4.4 Parameters to monitor and record

The following shall be monitored and recorded:

— test pressure;

— leakage.

5.2.5 Test No. 5 – Cylinder burst test

5.2.5.1 Procedure

The hydraulic burst test shall be carried out using a test rig, which allows pressure to be increased at a controlled rate.

The test shall be carried out at ambient test temperature and the temperature on the external surface of the cylinder shall be maintained at less than 50 °C. The rate of pressurization shall not exceed 10 bar per second and the duration of the test shall be at least 40 s.

The cylinder shall be pressurized at a controlled rate until failure, i.e. leakage through the pressure envelope or burst. The pressure against time curve or pressure against volume curve shall be plotted.

The maximum pressure achieved during the test shall be recorded as the burst pressure.

5.2.5.2 Criteria

The burst pressure shall be greater than or equal to the manufacturer's minimum specified design burst pressure and not less than 67,5 bar (see 4.4.1). Where the test is being conducted after completion of Test No. 7 (see 5.2.7), Test No. 8 (see 5.2.8), Test No. 9 (see 5.2.9) and Test No. 10 (see 5.2.10), the minimum burst pressure shall be 60 bar.

The cylinder shall not leak below the required burst pressure.

There shall be no fragmentation of the cylinder. Damage through impact during the burst test, which results in additional fragments, together with individual fibres and dust, shall be disregarded.

For cylinders manufactured from two parts joined together without liners, the burst shall not result in failure at the joint at a pressure below 85 bar. Where the test is being conducted after completion of Test No. 7 (see 5.2.7), Test No. 8 (see 5.2.8), Test No. 9 (see 5.2.9) and Test No. 10 (see 5.2.10), the burst shall not result in failure at the joint at a pressure below 75 bar.

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

5.2.5.3 Parameters to monitor and record

The following shall be monitored and recorded:

— burst pressure;

— number of pieces;

— description of failure, i.e. brittle fracture, ductile fracture, etc.; and

— pressure/time curve or pressure/volume curve.

5.2.6 Test No. 6 – Pressure cycle test

5.2.6.1 Procedure

The cycle test shall be carried out using a test rig which allows pressure to be increased and decreased at a controlled rate and automatically suspends the test when the cylinder has failed, either by leakage or rupture.

The test shall be carried out with a non-corrosive liquid subjecting the cylinder to successive reversals at an upper cyclic pressure not less than 30 bar. The value of the lower cyclic pressure shall not exceed 3 bar. The cylinder shall actually experience the upper and lower cyclic pressures during the test.

The cycle tests shall be carried out at ambient conditions and the temperature on the outside surface of the cylinder shall not exceed 50 °C during the test. The frequency of reversals of pressure shall not exceed 15 cycles per minute.

The temperature of the external surface of the cylinder shall be monitored at least twice a day.

The number of cycles achieved during the test shall be recorded.

After completion of this test, the cylinder shall then be destroyed (e.g. by bursting), or made incapable of holding pressure.

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

5.2.6.2 Criteria

The cylinder shall withstand 12 000 cycles without leakage.

5.2.6.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) the temperature of the external surface of the cylinder;

b) number of cycles achieving upper cyclic pressure;

c) minimum and maximum cyclic pressures;

d) cycle frequency;

e) test medium used; and

f) mode of failure, where appropriate.

5.2.7 Test No. 7 – Artificial ageing test

5.2.7.1 Procedure

Two closed cylinders, without the external coating unless this is an integral part of the design, shall be subject to the following tests for a total period of 60 days.

The cylinders shall be pressurized to not less than 20 bar and exposed to the environment, test reagents and exposure requirements, as follows:

a) 10 days in neutral salt spray (fog) in accordance with EN ISO 9227;

b) 10 days in a humid atmosphere containing sulphur dioxide in accordance with EN ISO 3231;

c) 10 days in fluorescent ultraviolet light and water in accordance with Test Method A in accordance with the requirements of Table 4 of EN ISO 16474-3:2013;

The cylinders shall then be depressurised and subject to a further 3 × 10 days testing as specified above.

The pressure shall be recorded at least at the beginning of the test and after 30 days, prior to de-pressurization.

Then, following the 60 day exposure:

1) one of the two cylinders shall be subjected to Test No. 5 (see 5.2.5);

2) the other cylinder shall be subjected to Test No. 6 (see 5.2.6).

After completion of Test No. 6 (see 5.2.6), the cylinder shall then be destroyed (e.g. by bursting), or made incapable of holding pressure.

NOTE It can be necessary to take precautions against over-pressurization during the test.

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

5.2.7.2 Criteria

For the first cylinder, the criteria shall be as specified in Test No. 5 (see 5.2.5).

For the second cylinder, the criteria shall be as specified in Test No. 6 (see 5.2.6).

5.2.7.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) the temperature of the test exposure, at least twice a day;

b) filling pressure;

c) duration of the exposure;

d) burst pressure;

e) description of failure; and

f) any visible corrosion of metallic parts, or alteration to non-metallic parts.

5.2.8 Test No. 8 – Exposure to elevated temperature at test pressure

5.2.8.1 Procedure

The test shall be conducted at (70 ± 5) °C and a relative humidity of less than 50 %.

Two cylinders shall be hydraulically pressurized to at least 30 bar, at the test temperature, and shall be maintained at this pressure for 2 000 h, alternatively, two cylinders shall be hydraulically pressurized to 60 bar, at the test temperature, and shall be maintained at this pressure for 500 hrs.

After this test, the cylinders shall be subjected to Test No. 5 (see 5.2.5);

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

Measures should be taken to minimize energy consumption and heat loss.

5.2.8.2 Criteria

The burst pressure shall be greater than or equal to 60 bar.

5.2.8.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) measurement of the water capacity before and after test;

b) temperature and relative humidity at least twice a day;

c) cylinder pressure at least twice a day; and

d) burst pressure.

5.2.9 Test No. 9 – Cylinder body integrity impact tests

5.2.9.1 General

The ability of the cylinder design (thickness, materials and mechanical properties) to withstand loadings other than internal pressure shall be demonstrated by a series of impact tests.

The tests shall be carried out at ambient conditions unless the manufacturer has opted for the alternative test permitted by 5.2.1.1.1 d), in which case the tests shall be carried out with the cylinders at –20 °C.

Each type of test shall be carried out on cylinders without internal pressure and cylinders pressurized to 20 bar.

The specified impact energy and striking velocity shall be achieved by striking the test cylinder with a moving striker or by dropping the cylinder from an appropriate height. In all cases, the location of the impact shall be as specified in the test procedure and the direction of impact shall intersect with the axis of the cylinder.

The strikers (flat surface and edge) shall be of metallic material having a hardness greater than that of the cylinder and sufficiently robust to prevent the impact energy being absorbed by deflection of the striker.

Where possible after completing of the tests all material should be processed for recycling

5.2.9.2 Flat surface impact test

5.2.9.2.1 Procedure

The striker shall be a flat surface with a length equal to the overall cylinder length and width equal to the cylinder diameter.

The impact energy, F, shall be determined by:

$$F = 30M$$

where

F is the energy, in joules;

M is the maximum operating mass of the cylinder, in kg.

The striking velocity shall be between 7 m/s and 8 m/s.

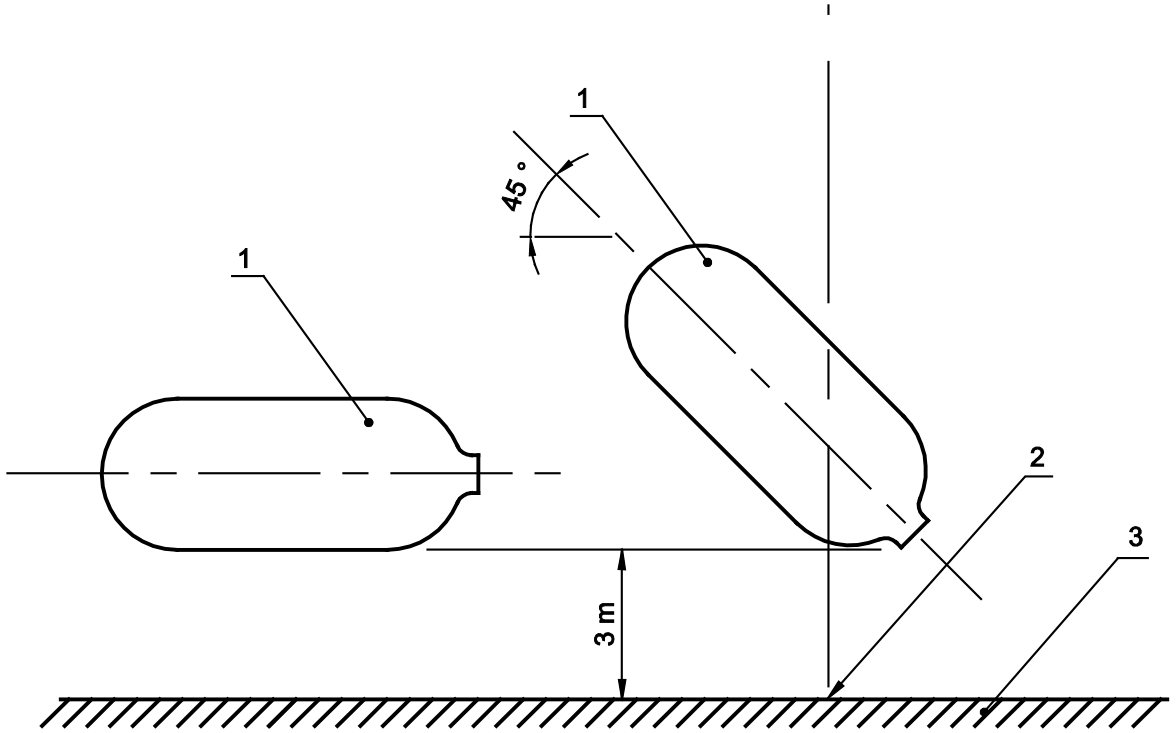
Two un-pressurized cylinders shall each be impacted with the surface parallel to the cylinder. The cylinders shall then be impacted on the shoulder of the end, with the surface at 45° to the cylinder axis (see Figure 1).

On completion of both impacts, the cylinders shall be visually examined for signs of damage and assessed against the rejection criteria established in accordance with EN 1439.

Where both cylinders show damage equal or worse than these rejection criteria, then both cylinders shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5).

Where one or both of the cylinders show no visible damage or damage below the rejection criteria, or where the rejection criteria has not been established, then one cylinder shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5) and the other subject to a pressure cycle test in accordance with Test No. 6 (see 5.2.6).

The tests shall be repeated with two further cylinders, which have been pressurized to 20 bar.



Key

1 cylinder
2 point of impact
3 flat surface

Figure 1 — Impact test with a flat surface

5.2.9.2.2 Criteria

After impacts, the pressurized cylinders shall not leak.

Cylinders subject to the burst test shall meet the requirements of Test No. 5 (see 5.2.5).

Cylinders subject to the pressure cycle test shall meet the requirements of Test No. 6 (see 5.2.6).

If both cylinders show damage equal or worse than these rejection criteria, then both cylinders shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5).

5.2.9.3 Edge impact test

5.2.9.3.1 Procedure

The profile of the striker shall be as shown in Figure 2 and the length shall be as shown in Figure 3.

The impact energy, *F*, shall be determined by:

$$F = 12M$$

where

F is the energy, in joules;

M is the maximum operating mass of the cylinder, in kg.

The striking velocity shall be between 4 m/s and 5 m/s.

Two un-pressurized cylinders shall each be impacted with the edge parallel to the cylinder axis (see Figure 3). The cylinders shall then be impacted with the edge perpendicular to the cylinder axis (see Figure 4). The position of the two impacts shall be separated by a minimum of 45° round the cylinder circumference.

Dimensions in millimetres

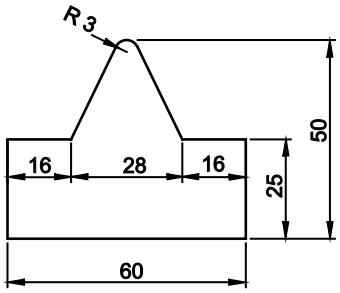
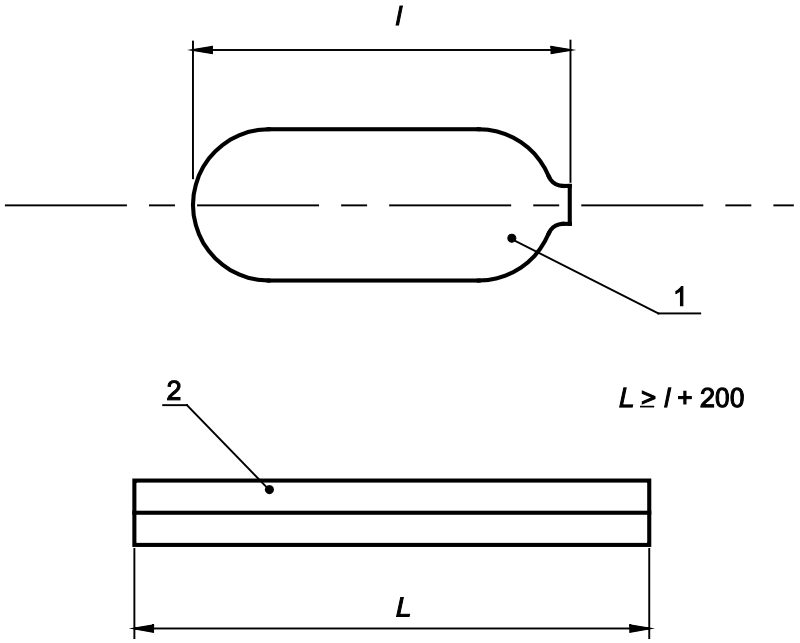


Figure 2 — Striker profile

Dimensions in millimetres

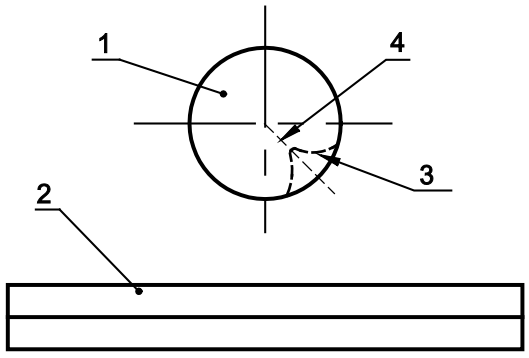


Key

1 test cylinder

2 striker (see Figure 2)

Figure 3 — Impact test with cylinder axis parallel to edge, *L*



Key

1 cylinder

2 striker (see Figure 2)

3 indentation from first drop

4 impact points to be separated by at least 45°

Figure 4 — Impact test with cylinder axis perpendicular to edge, *L*

On completion of both impacts, the cylinders shall be visually examined for signs of damage and assessed against the rejection criteria established in accordance with EN 1439.

If both cylinders show damage equal or worse than these rejection criteria, then both cylinders shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5).

Where one or both of the cylinders show no visible damage or damage below the rejection criteria, or where the rejection criteria has not been established, then one cylinder shall be subject to a burst test in accordance

with Test No. 5 (see 5.2.5) and the other subject to a pressure cycle test in accordance with Test No. 6 (see 5.2.6).

The tests shall be repeated with two further cylinders, which have been pressurized to 20 bar.

5.2.9.3.2 Criteria

After impacts, the pressurized cylinders shall not leak.

Cylinders subject to the burst test shall meet the requirements of Test No. 5 (see 5.2.5).

Cylinders subject to the pressure cycle test shall meet the requirements of Test No. 6 (see 5.2.6).

5.2.10 Test No. 10 – Drop test

5.2.10.1 Procedure

Two finished cylinders, including any foot-ring and/or valve protection and any removable protective sleeve, shall be weighted to represent the maximum operating mass and pressurized to 20 bar.

The cylinders shall each be dropped twice onto a flat surface from 1,2 m, in each of the five different orientations illustrated in Figure 5.

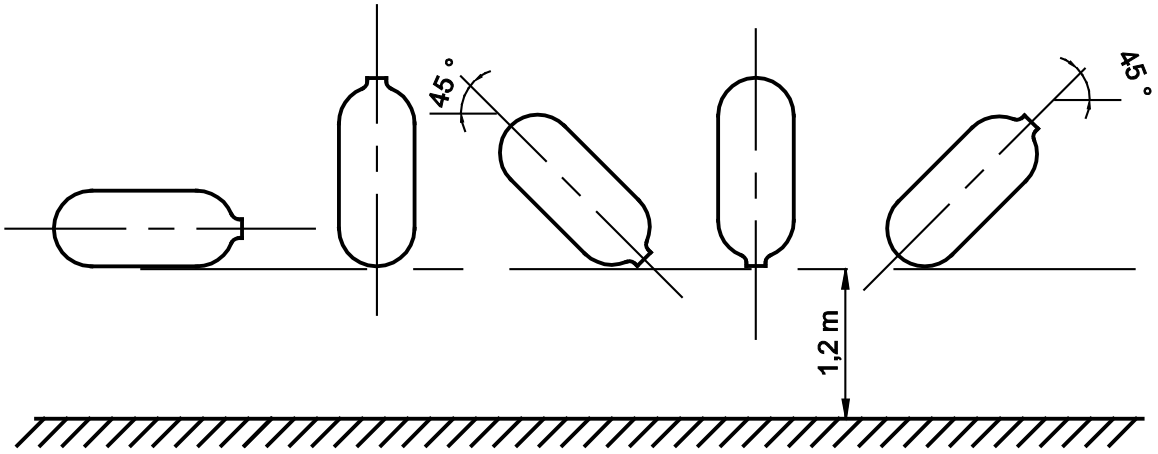


Figure 5 — Orientations for 1,2 m drop onto flat surface

The surface shall consist of a steel plate, 10 mm thick, sufficiently flat so that the difference between any two points on the surface is no more than 2 mm. It shall be replaced if the surface no longer meets this requirement. The plate shall rest on a flat, smooth concrete bed, at least 100 mm thick. The plate shall be in full contact with the concrete so that it is fully supported.

On completion of all 10 drops, one cylinder shall be visually examined for signs of damage and assessed against the rejection criteria established in accordance with EN 1439.

Where both cylinders show damage equal or worse than these rejection criteria, then both cylinders shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5).

Where one or both of the cylinders show no visible damage or damage below the rejection criteria, or where the rejection criteria has not been established, then one cylinder shall be subject to a burst test in accordance with Test No. 5 (see 5.2.5) and the other subject to a pressure cycle test in accordance with Test No. 6 (see 5.2.6).

Where possible after completing of the tests all material should be processed for recycling.

5.2.10.2 Criteria

After ten drops, the cylinders shall not leak.

The cylinder subject to the burst test shall meet the requirements of Test No. 5 (see 5.2.5).

The cylinder subject to the pressure cycle test shall meet the requirements of Test No. 6 (see 5.2.6).

5.2.11 Test No. 11 – Flawed cylinder test

5.2.11.1 Procedure

Two flaws, one longitudinal and the other transverse, shall be made on each of two cylinders in the central part along two planes forming an angle of approximately 120°. The flaws shall satisfy one of the following conditions, as appropriate:

a) For cylinders with metallic liners, the two flaws shall be made with a 1 mm thick cutter to a depth equal to at least 50 % of the composite overwrap thickness and a length at the bottom of the flaw equal to five times the composite overwrap thickness.

b) For cylinders with non-load sharing liners or without liners, the two flaws shall be made with a 1 mm thick cutter to a depth equal to at least 40 % of the composite overwrap thickness and a length at the bottom of the flaw equal to five times the composite overwrap thickness.

After introducing the flaws one of the two cylinders shall be subjected to Test No. 5 (see 5.2.5). The other cylinder shall be subjected to Test No. 6 (see 5.2.6) except that the upper cyclic pressure shall be 20 bar and the number of cycles shall be not less than 5 000.

After completion of Test No. 6 (see 5.2.6), the cylinder shall then be destroyed (e.g. by bursting), or made incapable of holding pressure.

Where possible after completing of the tests all material should be processed for recycling.

5.2.11.2 Criteria

For the first cylinder the burst pressure shall be greater than or equal to 40 bar.

The second cylinder shall withstand at least 1 000 pressure cycles to 20 bar without leakage. The cylinder can leak after the 1 000 cycles but shall fail the test if it bursts within 5 000 cycles.

5.2.11.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) burst pressure;

b) number of cycles;

c) flaw size;

d) description of failure; and

e) parameters as specified in Test No. 6 (see 5.2.6).

5.2.12 Test No. 12 – Extreme temperature cycle test

5.2.12.1 Vacuum cycling preconditioning

5.2.12.1.1 General

For cylinders with non-load sharing liners only, the cylinder shall either be subjected to a vacuum conditioning prior to the extreme temperature cycle test pressure cycling stages as specified in 5.2.12.2 or it shall be clearly marked in accordance with the requirements of Clause 7.

5.2.12.1.2 Procedure

The cylinder shall be subjected to a series of cycles from atmospheric pressure to a vacuum as follows:

a) The cylinder contents shall be evacuated to reduce the pressure to a pressure of 0,2 bar absolute at ambient temperature. The vacuum shall be maintained at this level for at least one min;

b) The pressure in the cylinder shall then be returned to atmospheric pressure; and

c) The above procedure shall be repeated for 50 cycles.

5.2.12.1.3 Parameters to monitor and record during the procedure

The following shall be monitored and recorded:

a) minimum and maximum cyclic pressures;

b) number of cycles; and

c) results of visual inspection.

5.2.12.2 Pressure cycling stages

5.2.12.2.1 Procedure

The cylinder and the contained pressurising medium shall be conditioned for 48 h at atmospheric pressure, at between 60 °C and 70 °C and at a relative humidity greater than or equal to 95 %.

The hydraulic pressurising medium, located in the circuit external to the cylinder under test, shall commence the cycle testing at ambient test temperature. 5 000 cycles shall be applied from a pressure approximately equal to atmospheric pressure to 20 bar. The cycle testing procedure shall be in accordance with Test No. 6 (see 5.2.6) but with the exception that the extreme temperature cycle test has temperature and humidity conditions as specified in this clause. The rate of pressure cycles for this test shall not exceed 5 cycles per minute to enable the temperature conditions to be maintained.

On completion of these cycles the pressure shall be released and the cylinder stabilized at ambient conditions.

The temperature shall then be reduced and the cylinder and the contained pressurising medium stabilized at a temperature between −50 °C and −60 °C.

The hydraulic pressurising medium, located in the circuit external to the cylinder under test, shall commence the second stage of cycle testing at ambient test temperature. 5 000 cycles shall be applied from a pressure approximately equal to atmospheric pressure to 20 bar. The environmental chamber containing the cylinder shall be maintained at the specified conditions by regulating the temperature. The cylinder skin temperature shall be measured and recorded.

On completion of these cycles the pressure shall be released and the cylinder stabilized at ambient conditions.

30 cycles shall be applied from atmospheric pressure to at least 30 bar.

Where possible after completing of the tests all material should be processed for recycling.

The test fluid should be processed for recycling.

Measures should be taken to minimize energy consumption and heat loss.

5.2.12.2.2 Parameters to monitor and record

The following shall be monitored and recorded:

a) temperatures during each part;

b) humidity during 1st part of test;

c) test medium used;

d) number of cycles, achieving upper cyclic pressure, at each stage;

e) minimum and maximum cyclic pressures;

f) cycle frequency; and

g) result of visual inspection.

5.2.12.3 Concluding burst test

5.2.12.3.1 General

The cylinder shall be subjected to Test No. 5 (see 5.2.5).

5.2.12.3.2 Criteria

The burst pressure shall be greater than or equal to 50 bar.

5.2.12.3.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) burst pressure;

b) description of failure.

5.2.13 Test No. 13 – Fire resistance test

5.2.13.1 Procedure

Two cylinders shall undergo this test:

— one in a horizontal position;

— one in a vertical position.

For the purpose of the test the cylinders shall be fitted with:

a) the service valve; or

b) a valve fitted with a bursting disc set to operate at between 30 bar and 34,5 bar; or

c) a valve fitted with a fusible plug set to operate at a minimum temperature of 100 °C.

The cylinders shall be filled with commercial propane (e.g. UN 1965 mixture C) to the maximum fill as defined in ADR.

A fire shall be created to ensure full fire engulfment for a minimum period of 30 min.

NOTE For guidance on suitable fire test see EN 3-7 [1], EN ISO 11439 [6] and CGA C14 [10].

One cylinder shall be placed in the horizontal position and the other upright with the valve uppermost. The fire shall be capable of enveloping the entire cylinder and valve, but in no case shall the flames be allowed to impinge directly on to the pressure relief device. This may be achieved by applying suitable protection to the valve.

After completion of this test the cylinders shall then be destroyed (e.g. by bursting) or made incapable of holding pressure.

Where possible after completing of the tests all material should be processed for recycling.

Measures should be taken to minimize energy consumption and heat loss.

5.2.13.2 Criteria

The cylinders shall not burst in a catastrophic way during the test. They are permitted to vent through the pressure relief device or leak through the cylinder wall or other surfaces.

5.2.13.3 Parameters to monitor and record during the test

The following shall be monitored and recorded:

a) type and characteristics of pressure relief device;

b) initial pressure;

c) time; and

d) mode of pressure release, if appropriate.

5.2.14 Test No. 14 – Spike puncture test

5.2.14.1 Procedure

The cylinder shall be pressurized to 20 bar with air, nitrogen or other inert gas. It shall be impacted by a steel spike, 10 mm diameter having a sharp point, with sufficient velocity to ensure complete puncturing of the cylinder wall. The point of impact shall be in the cylindrical part of the cylinder.

Where possible after completing of the tests all material should be processed for recycling.

5.2.14.2 Criteria

The tested cylinder shall reveal no evidence of a fragmentation failure.

5.2.14.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) description of the spike;

b) test pressure;

c) description of failure; and

d) approximate size and location of the puncture opening.

5.2.15 Permeability test of cylinders with non-metallic liners or without liners

5.2.15.1 Procedure

One cylinder shall be hydraulically cycled 1 000 times from 0 bar to 20 bar before being emptied and thoroughly dried. It shall then be re-valved, weighed and the empty weight recorded.

The cylinder shall be pressurized with test gas to 20 bar and the valve and the junctions of the non-metallic liner or composite with metallic bosses or rings shall be visually checked for leaks e.g. with soapy water (bubble test). The test gas shall have a permeability of at least the LPG to be contained. Any leaks shall be eliminated before proceeding with the test. The test cylinder shall be depressurised and weighed empty.

The cylinder shall then be filled with commercial propane (e.g. UN 1965 mixture C) to the maximum fill as defined in ADR. The cylinder shall then be heated to 40 °C. The temperature shall be maintained constant for the duration of the test.

The cylinder shall be weighed and the weight of the gas stored determined and recorded. The cylinder shall then be re-weighed periodically throughout the test to determine the rate of weight loss. Once a steady rate of loss has been achieved, the test shall continue for a further 500 h.

After the test the cylinder shall be re-weighed empty. Any difference in weight between this measurement and the initial measurement shall be used to determine the effect due to moisture absorption and the weights obtained during the test shall be modified accordingly.

Alternative procedures may be used, providing they can be demonstrated to achieve the same accuracy of results.

Where possible after completing of the tests all material should be processed for recycling.

The commercial Propane should be recycling.

5.2.15.2 Criteria

The maximum rate of weight loss shall not exceed 1 mg/h/l water capacity.

5.2.15.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) test gas used;

b) cycle test medium;

c) number of cycles, achieving upper cyclic pressure;

d) cycle frequency;

e) environmental temperatures and humidity at least twice a day;

f) cylinder weights;

g) rate of weight loss; and

h) time after achieving steady rate of loss.

5.2.16 Test No. 16 – Torque test

5.2.16.1 Procedure

The cylinder threads shall show no permanent expansion or deformation when mated with a corresponding valve or plug and tightened to 110 % of the maximum torque specified and to the procedure specified in EN ISO 14245 or EN ISO 15995, or as recommended in the manufacturer's specification where this European Standard does not apply. The internal neck thread shall be checked using gauges corresponding to the agreed neck thread to ensure that it is within tolerance.

NOTE Where the neck thread is specified to be in accordance with EN ISO 11363-1, the corresponding gauges are specified in EN ISO 11363-2.

Where special clamping arrangements are required to prevent rotation of the cylinder/neck boss, these shall be specified by the cylinder manufacturer.

Where possible after completing of the tests all material should be processed for recycling

5.2.16.2 Criteria

The threads shall remain within gauge tolerance.

5.2.16.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) type of valve/plug material;

b) valving procedure; and

c) applied torque.

Where the torque recommended by the manufacturer differs from that specified in EN ISO 14245 or EN ISO 15995, this shall be recorded on the label (see Clause 7).

5.2.17 Test No. 17 – Neck strength test

5.2.17.1 Procedure

The neck of the cylinder shall show no significant deformation and shall remain within the drawing tolerance when mated with a corresponding valve or plug and tightened to 150 % of the torque specified and to the procedure specified in EN ISO 14245 or EN ISO 15995 or as recommended in the manufacturer's specification, where this standard does not apply.

Where special clamping arrangements are required to prevent rotation of the cylinder/neck boss, these shall be specified by the cylinder manufacturer.

Where the neck contains a threaded insert, the cylinder shall be pressurized to a minimum of 6 bar for a minimum of 20 minutes and a leak test shall be carried out.

NOTE The leak test can be a water jacket test, helium gas detection test, permeability test in accordance with Test No. 15 (see 5.2.15) or a suitable alternative that demonstrates an equivalent level of safety.

Where possible after completing of the tests all material should be processed for recycling.

5.2.17.2 Criteria

The neck shall show no significant deformation or movement relative to the cylinder.

Leakage shall not be greater than the criteria of Test No. 15 (see 5.2.15) or the calculated equivalent in case of using an alternative test method.

5.2.17.3 Parameters to monitor and record

The following shall be monitored and recorded:

a) type of valve/plug material;

b) valving procedure;

c) applied torque; and

d) parameters required in Test No. 15 (see 5.2.15), where applicable.

Where the torque recommended by the manufacturer differs from that specified in EN ISO 14245 or EN ISO 15995, this shall be recorded on the label (see Clause 7).

5.2.18 Test No. 18 – Neck ring test

When a neck ring is fitted, the manufacturer shall demonstrate that the axial load required to remove the neck ring is greater than 10 × the gross mass of the full cylinder and not less than 1 000 N. The minimum torque to turn the neck ring shall be greater than 100 Nm.

Where possible after completing of the tests all material should be processed for recycling.

5.3 Failure to meet test requirements

5.3.1 Metallic liners

Where the mechanical properties of the liner have not met the requirements of the specification, they may be treated in accordance with the appropriate clauses of the relevant standard, as listed in 4.2.1.

5.3.2 Complete cylinder

5.3.2.1 For complete cylinders (cylinders without permanently fixed parts), the following procedure may be used for prototype testing, design variant testing and production testing.

5.3.2.2 In the event of failure to meet test requirements, re-testing shall be carried out, as follows:

— Where there is evidence of a fault in carrying out a test, or an error of measurement a second test shall be performed on the same cylinder where possible. If the results of this test are satisfactory, the first test shall be ignored;

— Where the test has been carried out in a satisfactory manner, the cause of test failure shall be identified or the batch(es) shall be rendered unserviceable. If the cause of failure is identified the defective cylinders may be rectified or shall be rendered unserviceable. If reclaimed, these acceptable cylinders along with the original satisfactory cylinders shall be considered a new batch and the prototype testing and/or batch test shall be performed again. If any test or part of a test is unsatisfactory, all the cylinders of the batch covered by the test shall be rendered unserviceable.

5.3.2.3 For production testing only:

— Where a cylinder within a group of batches has been subjected to a burst test and a failure occurs, one cylinder from each of the batches within the group shall be subjected to a burst test in accordance with Test No. 5 (see 5.2.5). If any test or part of a test is unsatisfactory, all the cylinders of the batch covered by these unsatisfactory tests shall be rendered unserviceable;

— where a cylinder within a group of batches has been subjected to a pressure cycle test and a failure occurs, one cylinder from each of the batches within the group shall be subjected to a pressure cycle test in accordance with Test No. 6 (see 5.2.6). If any test or part of a test is unsatisfactory, all the cylinders of the batch covered by these unsatisfactory tests shall be rendered unserviceable.

Where possible all material and rejected cylinders should be processed for recycling

6 Conformity assessment

Cylinders designed and manufactured according to this standard are subject to the conformity assessment system outlined in Annex A. This will consist of the prototype and design variant testing, approval of the design type, the production testing with the initial inspection, testing of batches and all cylinders manufactured according to the design type.

NOTE Detailed regulations on the conformity assessment system and the approval for the manufacture of pressure receptacles are outlined in RID/ADR.

7 Marking

7.1 Each cylinder shall be marked clearly and legibly in accordance with EN 14894.

7.2 Specific additional information shall be included as follows:

— where a cylinder with non-load sharing liner has not completed the vacuum conditioning of the extreme temperature cycle test (Test No. 12, see 5.2.12) the following words shall be marked clearly, legibly and indelibly:

“WARNING – THIS CYLINDER MUST NOT BE SUBJECTED TO A VACUUM OR BE FILLED WITH BUTANE”

— any restriction on valve torque.

An encapsulated, printed label can be used provided it is clearly legible through the encapsulating material.

7.3 Where marking is on the ends of cylinders it shall be demonstrated in the pressure cycle and burst test that failure does not initiate in the markings and the markings are legible.

NOTE The marking provisions of RID/ADR do not allow the marking on the bottom end of the cylinder.

Annex A
(normative)

Prototype testing, design variant testing and production testing

A.1 General

This annex describes the tests to be carried out to verify new cylinder designs (prototype testing), to extend prototype testing to permitted variants (design variant testing) and also to ensure compliance of a production batch of cylinders with the design specification of the prototype cylinder design (production tests).

Some of the test requirements are specified in Clause 5. The applicability and number of tests, including tests not described in Clause 5, are specified in Table A.1, Table A.2, Table A.3, Table A.4 and Table A.5.

In order to demonstrate consistency of production quality (homogeneity) within a batch, it may be necessary for the manufacturer to carry out additional tests on non-metallic liners and cylinders without liners. The type of test will depend on the materials used and the manufacturing processes. Any such test should be shown to be effective during prototype testing.

Reference should also be made to EN 1439, which requires the cylinder manufacturer to perform additional tests to determine the rejection limits for in-service damage and to include these limits in the documentation for the cylinder.

Consideration should be given to minimising the environmental impact of the tests specified by including the possible recovery of test fluids, recycling of mechanical test specimens, safe disposal of chemicals and destroyed cylinders, etc.

A.2 Prototype testing

A.2.1 General

Prototype testing shall be carried out on each new design of cylinder.

All the tests shall be carried out on cylinders of identical design (i.e. materials, liner, manufacturing process) from the same factory, equipment and the same sub-contractor, if applicable. The tests shall be performed on cylinders having the same nominal dimensions (i.e. same diameter, length, liner wall thickness and composite thickness).

A set of prototype tests is valid for cylinders having the same diameter but whose length may vary from twice the diameter of the prototype tested cylinder to 1,5 times the length of the prototype tested cylinder. However, any increase in length of the cylinder compared with the prototype tested shall require a repeat of the Tests No. 9 (see 5.2.9) and Test No. 10 (see 5.2.10), using cylinders of the new length.

Shorter cylinders i.e. those cylinders whose length is less than twice the diameter of the nominated prototype tested cylinder shall not be considered part of the family and shall be tested individually as a design variant (see A.3).

A.2.2 Definition of new design

A cylinder shall be considered to be of a new design, compared with a previously prototype tested cylinder, when any of the following conditions apply if:

a) it is manufactured in a different factory;

b) it is manufactured by a significantly different process that materially affects the performance of the liner and/or finished cylinder;

c) the liner is manufactured from a material of different composition or outside the composition limits of the material used in the original prototype tested design and/or detailed in the relevant standard listed in 4.2.1;

d) it is manufactured with a new fibre type;

e) a fibre shall be considered to be of a new fibre type when any of the following conditions apply:

   1) the fibre is of a different classification, e.g. glass, aramid, carbon;

   2) the fibre is produced from a different precursor (starting material), e.g. polyacrylonitrile (PAN), pitch for carbon;

   3) the nominal fibre modulus, specified by the fibre manufacturer, differs by more than ± 5 % from that defined in the prototype tested design;

   4) the nominal fibre strength, specified by the fibre manufacturer, differs by more than ± 5 % from that defined in the prototype tested design;

f) the cylinder diameter has changed by more than 50 %;

g) the autofrettage pressure has changed by more than 5 %;

h) it is manufactured using not equivalent matrix materials (if applicable) e.g. resin, curing agent, accelerator. Where a new matrix material has been prototype tested for an existing design, then all the manufacturer's existing prototype tested designs are regarded as prototype tested with the new matrix system without the need for any additional prototype testing;

i) a matrix shall be considered to be of a new matrix type when any of the following conditions apply:

   1) the matrix is of a different classification, e.g. polyester, vinyl ester, epoxy;

   2) the matrix is produced from a different base material, e.g. bis-phenol A, epoxy, metacrylic acid;

   3) the nominal matrix elongation at break, specified by the matrix manufacturer, is lower than 5 % from that defined in the prototype tested design;

   4) the nominal glass transitional temperature, specified by the matrix manufacturer, is lower than 5 % from that defined in the prototype tested design.

A.2.3 Prototype testing requirements

The applicant for prototype testing shall, for each new design of cylinder, submit the documentation necessary for the checks specified below. The applicant shall make available a batch of at least 50 cylinders, from which the number of cylinders required for the tests referred to below will be taken. For cylinders with liners the applicant shall also submit a suitable number of liners for testing taken at random from the same batch prior to winding.

However, if the total production is less than 50 cylinders, enough cylinders shall be made to complete the prototype testing in addition to the production quantity, but in this case the prototype testing validity is limited to this particular production batch.

In the course of the prototype testing process, it shall be verified that:

a) the necessary cylinders for testing are selected in accordance with Table A.1, Table A.2, Table A.3 and Table A.4, as applicable;

b) the design conforms to the requirements of Clause 4;

c) the liners are in accordance with the relevant liner design standard and in compliance with the manufacturing drawing;

d) the internal and external surfaces of the cylinders are free of any defect which may make them unsafe to use;

e) the tests are carried out in accordance with Tables A.1, A.2, A.3 and A.4, as applicable.

Table A.1 — Composite materials

Test / inspection / check	Prototype testing and design variant testing	Production testing
	No. / extent of tests	**No. / extent of tests**
Test No. 1 – All cylinders		
a) – Tensile properties of fibres	2	1 test per batch of fibres
b) – Shear properties	2	1 test per batch of fibres
c) – impact properties [a]	2	-
Test No. 1 – Cylinders without liners		
Tensile Strength	1	1
Tensile modulus	1	1
Elongation	1	1
Viscosity	1	-
Heat distortion temperature	1	-
Auto-ignition temperature	1	-
Composition	1	-
[a] See 5.2.1.1.1 c) for alternative tests.		

A.2.4 Prototype testing certificate

Where the results of the prototype testing are satisfactory, the design type specification shall be declared as compliant with this standard and a certificate shall be issued, a typical example of which is given in Annex B.

Where the results are not satisfactory proceed in accordance with 5.3.

Table A.2 — Metallic liners

Test / inspection / check	Prototype testing and design variant testing	Production testing
	No. / extent of tests	**No. / extent of tests**
Test No. 2 – Liner material tests (see 5.2.2) to the appropriate standard [a]	Quantity prescribed by appropriate standard	-
Test No. 2 – Liner material tests (see 5.2.2) to the appropriate standard [a] – mechanical properties only	-	1 per liner batch
Test No. 3 – Liner burst test (see 5.2.3)	1	-
Visual inspection	100 %	10 %
Dimensional check	100 %	10 %
[a] For list of appropriate standards see 5.2.2.		

Table A.3 — Non-metallic liners

Test / inspection / check	Prototype testing and design variant	Production testing
	No. / extent of tests	**No. / extent of tests**
Test No. 2 – Materials tests [a]	2	1 [b]
Visual inspection	100 %	10 %
Dimensional check	100 %	10 %
[a] For list of appropriate standards see 5.2.2. [b] Only melting flow index (thermoplastic), viscosity (all), melting point (thermoplastic) and glass transition temperature (thermoset) tests shall be carried out on each batch of material.		

A.3 Design variant testing

A.3.1 General

A reduced testing programme may be carried out for cylinders within the definition of a design variant compared with that required for a prototype testing. Design variant testing shall be conducted for each design variant of a cylinder.

A.3.2 Definition of a design variant

A.3.2.1 Conditions to be satisfied

A cylinder shall be considered to be a design variant, compared with a previously prototype tested cylinder, when any of the following conditions apply:

a) the fibres in the design are equivalent to the fibres in a previously prototype tested cylinder (see A.3.2.2);

b) the liner in the design is equivalent to the liner in a previously prototype tested cylinder (see A.3.2.3);

c) the cylinder conforms to the conditions in A.3.2.5.

A.3.2.2 Equivalent fibre

For a fibre having similar nominal mechanical and physical characteristics to the prototype tested fibre, its equivalency shall be verified as follows before it can be considered as an equivalent fibre.

The new fibre with the existing prototype tested resin system, if applicable, shall be subjected to the strand and interlaminar shear tests detailed in Test No. 1 (see 5.2.1).

The mechanical properties shall be within ± 5 % of the nominal properties of the prototype tested fibre.

Where a new equivalent fibre has been prototype tested for an existing design, then all the manufacturer's existing prototype tested designs are regarded as prototype tested with the new fibre without the need for any additional prototype testing.

A.3.2.3 Equivalent Matrix

For a matrix having similar nominal mechanical and physical characteristics to the prototype tested matrix, its equivalency shall be verified as follows before it can be considered as an equivalent matrix.

The new matrix with the existing prototype tested resin system, if applicable, shall be subjected to Test No. 1 (see 5.2.1).

The mechanical properties shall be within ± 5 % of the nominal properties of the prototype tested matrix.

Where a new equivalent matrix has been prototype tested for an existing design, then all the manufacturer's existing prototype tested designs are regarded as prototype tested with the new matrix without the need for any additional prototype testing.

Table A.4 — Tests on finished cylinders

Test / inspection / check	Prototype testing and design variant testing	Production testing
	No. / extent of tests	**No. / extent of tests**
Visual inspection	100 %	100 % [d]
Autofrettage check (if applicable)	100 %	100 % [d]
Dimensional check[c]	100 %	1 per batch
Weight check[c]	100 %	1 per batch
Water capacity check[c]	100 %	1 per batch
Marking compliance check[c]	100 %	1 per batch
Neck thread checks[c]	100 %	1 per batch
Test No. 4 – Hydraulic (or proof) test (see 5.2.4)	100 %	100 %
Test No. 5 – Cylinder burst test (see 5.2.5)	3	1 per batch [e]
Test No. 6 – Pressure cycling test (see 5.2.6)	2	Minimum of 1 per 5 batches
Test No. 7 – Artificial ageing test (see 5.2.7)	2	-
Test No. 8 – Exposure to elevated temperature at test pressure (see 5.2.8)	2	-
Test No. 9 – Cylinder body integrity impact test (see 5.2.9)	8	-
Test No. 10 – Drop test (see 5.2.10)	2	-
Test No. 11 – Flawed cylinder test (see 5.2.11)	2	-
Test No. 12 – Extreme temperature cycle test [a] (see 5.2.12)	1	-
Test No. 13 – Fire resistance test (see 5.2.13)	2	-
Test No. 14 – Spike puncture test (see 5.2.14)	1	-
Test No. 15 – Permeability test [b] (see 5.2.15)	1	-
Test No. 16 – Torque test (see 5.2.16)	1	-
Test No. 17 – Neck strength test (see 5.2.17)	1	-
Test No. 18 – Neck ring test (where applicable) (see 5.2.18)	1	-

[a] For Test No. 12 (see 5.2.12) the vacuum conditioning is optional for cylinders with non-metallic liners and cylinders without liners.

[b] The permeability test is required for cylinders with non-metallic liners and cylinders without liners.

[c] If one unacceptable defect is found, 100 % of the cylinders in the batch shall be inspected.

[d] May be combined with hydraulic Test No. 4 (see 5.2.4). It is possible to reduce the inspection to 10 % provided the manufacturer can demonstrate that his process provides an equivalent level of assurance.

[e] Refer to A.4.5.1

A.3.2.4 Equivalent liner

An equivalent liner is defined when the liner is of the prototype tested design except when any one of the following conditions apply:

a) manufactured in a different factory;

b) manufactured using a significantly different process that materially affects the performance of the liner; or

c) given a heat treatment outside the limits specified in the prototype tested design.

The new equivalent liner shall be subjected to the material tests specified in the relevant standards, as listed in 5.2.2, and to the liner burst test, in accordance with Test No. 3 (see 5.2.3), and shall meet the minimum requirements of the prototype tested design.

Where a new equivalent liner has been prototype tested for an existing design, then all the manufacturer's existing prototype tested designs are regarded as prototype tested with the new liner without the need for any additional prototype testing.

A.3.2.5 Cylinder variant

A cylinder shall be considered to be a design variant, compared with a previously prototype tested cylinder, when any one of the following conditions apply:

a) the nominal length of the cylinder has changed to less than 2 x diameter or has increased by more than 50 % of the prototype design tested;

b) the nominal outside diameter has changed by more than 2 % and less than or equal to 50 %. Where the change in nominal diameter is between 2 % and 20 %, a different test regime shall be applied compared to that for changes between 20 % and 50 % in accordance with Table A.5;

c) there have been changes to the composite thickness or wrap pattern;

d) there have been changes to the thickness of the liner, i.e. wall or base thickness has changed;

e) the liner has material properties outside the prototype tested design limits;

f) the liner is equivalent to an existing prototype tested design, as specified in A.3.2.4;

g) the matrix is equivalent to an existing prototype tested design, as specified in A.3.2.3

h) the new fibre is equivalent to the fibre in the prototype tested design as specified in A.3.2.2;

i) the neck thread size has changed;

j) the nominal autofrettage pressure has changed by 5 % or less, of the prototype tested design autofrettage pressure.

A.3.3 Design variant test requirements

For each design variant, the applicant for design variant testing shall submit the documentation necessary for the checks specified below. The applicant shall also make available a batch of cylinders equal to twice the quantity of cylinders required for design variant testing together with any additional information required. In addition the prototype testing certificate of the original design shall be presented.

For cylinders with metallic liners, the applicant shall also submit at least one liner taken at random from the same batch just prior to winding.

In the course of the design variant testing process, it shall be verified that:

a) the required level of testing is determined by consideration of the changes in the design variant compared with the previously tested prototype;

b) the necessary cylinders selected for testing are in accordance with Table A.5;

c) the design conforms to the requirements of Clause 4;

d) the design is in accordance with the manufacturing drawing;

e) the internal and external surfaces of the cylinders are free of any defect which may make them unsafe to use;

f) the tests as specified in Table A.5 are carried out.

A.3.4 Design variant testing certificate

Where the results of the design variant testing are satisfactory the design variant specification shall be declared as compliant with this standard and a certificate shall be issued, a typical example of which is given in Annex B.

If the results are not satisfactory proceed as described in 5.3.

Table A.5 — Design variant test requirements

Test No.	Test	New design	Design variant changes									
			Nominal length L		Nominal diameter D		Liner design or thickness	Composite thickness or wrap pattern	Fibre	Equivalent Matrix	Neck thread change	Auto-frettage pressure
			New length < 2D	New length > 1,5L	Changed by > 2 % and ≤ 20 %	Changed by > 20 % and ≤ 50 %						
1	Composite material	✓						✓[f]		✓		
2	Liner material	✓					✓[e]					
3	Liner burst [a]	✓		✓	✓	✓	✓					
4	Hydraulic proof	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
5	Cylinder burst	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
6	Pressure cycle	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
7	Artificial aging	✓										
8	Exposure to elevated temperature	✓				✓		✓				
9	Cylinder body integrity impact	✓		✓		✓	✓	✓	✓	✓		
10	Drop	✓		✓		✓	✓	✓	✓	✓		
11	Flawed cylinder	✓				✓		✓				
12	Extreme temperature cycle	✓						✓				
13	Fire resistance	✓				✓[d]						
14	Spike puncture	✓										
15	Permeability [b]	✓				✓	✓					
16	Torque	✓									✓	
17	Neck strength	✓			✓	✓	✓				✓	
18	Neck ring [c]	✓										

[a] Cylinders with load bearing liners only.
[b] Cylinders with non-metallic or no liners.
[c] Cylinders with neck rings fitted only.
[d] For cylinders leaking in the type approval bonfire test at a pressure > test pressure it is not necessary for this test to be carried out.
[e] For equivalent liner testing.
[f] For equivalent fibre testing.

A.4 Production testing

A.4.1 General

These tests are a series of tests that shall be carried out on either the whole or part of the production batch, as identified in A.4.2, A.4.3, A.4.4 and A.4.5, to ensure the compliance of the batch with the design specification.

A.4.2 Production test requirements

A.4.2.1 For the purpose of production testing, the cylinder manufacturer shall provide the following information:

a) the prototype testing certificate or the design variant testing certificate;

b) the material certificates stating the analyses of the liner material and composite materials;

c) the certificates of compliance stating that the composite overwrap materials meet the supply specifications and report of material testing in accordance with Table A.1;

d) heat treatment documentation, as appropriate;

e) certificates covering any non-destructive testing of the liner, if applicable;

f) the serial numbers of the cylinders;

g) a statement of the thread checking method used and results thereof.

A.4.2.2 During production testing, the following checks and verifications shall be carried out:

a) check that the prototype testing certificate or design variant testing certificate has been obtained and that the cylinders conform to it;

b) check whether the information supplied by the manufacturer referred to in A.4.2.1 is correct;

c) check that the necessary liners have been selected for testing in accordance with A.4.3.1 or A.4.3.2, as appropriate;

d) verify that composite materials meet the test requirements, specified in A.4.4;

e) check whether the requirements set out in Clause 4 have been met and the inspections required by A.4.5.2, have been carried out;

f) check that the necessary cylinders have been selected for testing in accordance with A.4.5.1;

A.4.3 Liner batch tests and inspections

A.4.3.1 Metallic liner

The inspections and tests shall be carried out on a batch of metallic liners as specified in Table A.2.

The liner shall comply with the design drawing of the prototype and the supply specifications. The inspections shall include both non-destructive tests, i.e. visual, dimensions, etc., and destructive tests i.e. tensile tests.

A.4.3.2 Non-metallic liner

The inspections and tests shall be carried out on a batch of non-metallic liners as specified in Table A.3.

The liner shall comply with the design drawing and the supply specifications. The inspections shall include at least the non-destructive inspections - visual, dimensional, weight, etc., and any appropriate destructive tests.

The measured parameters shall not be less than the minimum design requirement.

Acceptance of non-metallic liners shall also depend on satisfying the following requirements:

— the properties of the material (raw material as granulate, etc.) shall be within the tolerances set by the material manufacturer;

— the process parameters during liner manufacturing shall be within the tolerances agreed during prototype testing of the process;

— the material properties of the liner shall be within the tolerances required by the design requirements. This shall be verified by testing the material from a liner.

A.4.4 Composite materials batch tests and inspections

The tests and inspections shall be carried out on a batch of composite material, fibre, matrix, resin, and adhesive, if applicable, as specified in Table A.1.

The materials shall comply with the design drawing of the prototype and the supply specifications.

A.4.5 Tests and inspections of the finished cylinder

A.4.5.1 Tests

A.4.5.1.1 For cylinders with non-load sharing liners (non-metallic or welded metallic) or without liners, the manufacturer shall apply tests appropriate to the manufacturing process to demonstrate that the cylinder does not leak.

A.4.5.1.2 The tests shall be carried out on a batch of finished cylinders with liners or batch of finished cylinders with no liners as specified in Table A.4, as follows:

a) the hydraulic proof test (Test No. 4, see 5.2.4) on all cylinders;

b) a hydraulic burst test (Test No. 5, see 5.2.5) on one cylinder per batch;

It can be instructive to compare the results of the hydraulic burst test (Test No. 5, see 5.2.5) on the prototype test cylinders, the design variant test cylinders and production test cylinders. If the results of the hydraulic burst test (Test No. 5, see 5.2.5) from the design variant testing and production testing are consistently less than 85 % of the minimum of the burst tests obtained during prototype testing, the cause of the variation should be determined. Similarly, the maximum burst pressure should not be more than 150 % of the minimum burst pressure specified by the manufacturer.

c) a pressure cycling test (Test No. 6, see 5.2.6) on not less than one cylinder per five batches (i.e. a maximum of 1 000 cylinders produced sequentially).

A.4.5.1.3 For large volume manufacture, the frequency of sampling may be modified as follows

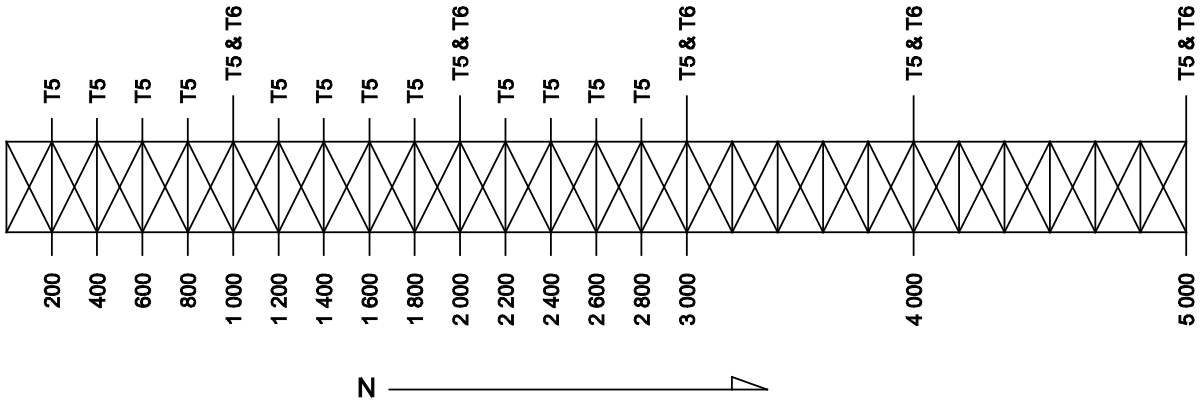
a) Following the successful testing of 15 batches of cylinders (in conformance with a single prototype) consecutively manufactured, the Burst Test (Test 5, see 5.2.5) frequency may be reduced to every 5th batch. The reduced rate of sampling for large volume manufacture (above 3 000 cylinders) shall only be applied where the manufacturer can demonstrate that the batch production test results and manufacturing processes are consistently reliable without any major interruption of manufacture.

NOTE In this context “consecutively” need not imply continuous production.

b) When selecting cylinders for testing from a group of 5 batches they should be selected from the last batch manufactured.

c) When Burst Testing (Test 5, see 5.2.5) every 5th batch if a cylinder fails the Burst Test (Test 5, see 5.2.5) each of the previous 4 batches shall be Burst Tested (Test 5, see 5.2.5). If a cylinder fails the Pressure Cycle Test (Test 6, see 5.2.6) one cylinder from each of the previous 4 batches shall be Pressure Cycle Tested (Test 6, see 5.2.6).

d) If a cylinder fails a Burst Test (Test 5, see 5.2.5) or Pressure Cycle Test (Test 6, see 5.2.6) the testing frequency process shall start again from the next batch successfully tested and a further 14 batches shall be successfully tested before the Burst Test (Test 5, see 5.2.5) frequency can be reduced to every 5th batch.



Key

Batch of 200 finished cylinders

N Number of cylinders manufactured

T5 Test No. 5 = Cylinder burst test (see 5.2.5)

T6 Test No. 6 = Pressure cycle test (see 5.2.6)

Figure A.1 — Cylinder burst and pressure cycle test frequency for large volume production of cylinders in conformance with a single prototype

A.4.5.2 Inspections

The inspections shall be carried out on a batch of finished cylinders with liners or batch of finished cylinders with no liners as specified in Table A.4, as follows:

a) visual inspection, in accordance with 4.4.4 - 100 % (refer to Table A.4, footnote [d]);

b) dimensional check - 1 per batch of finished cylinders;

c) weight check - 1 per batch of finished cylinders;

d) water capacity check - 1 per batch of finished cylinders;

e) compliance of marking - 1 per batch of finished cylinders.

For b), c), d), and e) if one unacceptable cylinder is found then 100 % of the cylinders in the batch shall be inspected.

A.4.6 Batch acceptance certificate

Where the results of the checks and tests are satisfactory, a production testing certificate shall be issued.

NOTE A typical example of a production testing certificate is given in Annex B.

Where the results are not satisfactory proceed as described in 5.3.

Annex B
(informative)

Examples of type approval and production testing certificates

B.1 Type approval certificate - composite cylinders with metallic liners

Issued by .....*(Relevant authority)*.....on the basis of applying ADR ……. *(year)* and EN 14427, *LPG equipment and accessories - Transportable refillable composite cylinders for LPG — Design and construction*

Approval No.° ..... Date .....…….....

Approval Expires on ……..*(the date of expiry of the type approval)*

Cylinder description..……..*(Family of cylinders which has received type approval)* ….....

Manufacturer's drawing No: .. ..…….....

Design life……..…… Special torque …….Pressure Relief Device…..……..……...……

Liner heat treatment details..... ....

Finished cylinder		**Liner**		**Composite material**	
Capacity	litres	Material		Fibre(s)	
Test Pressure	bar	Min. thickness	mm	Fibre(s) tensile strength	MPa
Diameter	mm	Min. yield stress	MPa	Fibre(s) Modulus	GPa
Length	mm	Min. tensile strength	MPa	Matrix components	
Thread		Elongation	%	Shear strength	MPa
Autofrettage pressure	bar	Min. burst pressure	bar	Thickness	mm

Compatible gases: .....

Manufacturer or agent.....*(Name and address of manufacturer or its agent)*.....……..... …...

.....…….....

.....…….....

.....…….....

Type approval mark .....…….....

Details of the results of the examination of the design for type approval are detailed in

Report .....

All information may be obtained from.....*(Name and address of the approving body)* .....

.....…….....

.....…….....

Date Place .....……

Signature .....……

B.2 Type approval certificate - composite cylinders with non-metallic liners

Issued by .....*(Relevant authority)*.....on the basis of applying ADR …….. *(year)* and EN 14427, *LPG equipment and accessories - Transportable refillable composite cylinders for LPG — Design and construction*

Approval No .....Date .....

Approval Expires on ……..*(the date of expiry of the type approval)*

Cylinder description ……..*(Family of cylinders which has received type approval)*……..

Manufacturer's drawing No: .....

Design life…… Special torque ……..Pressure Relief Device……

Finished cylinder		**Liner**		**Composite material**	
Capacity	litres	Material		Fibre(s)	
Test pressure	bar	Density		Fibre(s) tensile strength	MPa
Diameter	mm	Melting point	°C	Fibre(s) modulus	GPa
Length	mm	Glass transition temperature	°C	Matrix components	
Thread		Auto-ignition temperature	°C	Shear strength	MPa
		Min. thickness	mm	Thickness	mm

Metal End Boss			
Material	Min. yield stress	Min. tensile strength	Elongation
	MPa	MPa	%

Compatible gases: .....

Manufacturer or agent.....*(Name and address of manufacturer or its agent)*.....

.....

.....

.....

Type approval mark .....

Details of the results of the examination of the design for type approval are detailed in

Report ……..

All information may be obtained from..... *(Name and address of the approving body)*.....

.....

.....

.....

Date ..... Place .....

Signature .....

B.3 Type approval certificate - composite cylinders without liners

Issued by .....*(Relevant authority)*.....on the basis of applying ADR …….*(date)* and EN 14427, *LPG equipment and accessories - Transportable refillable composite cylinders for LPG — Design and construction*

Approval N° ..... Date……

Approval Expires on ……..*(the date of expiry of the type approval)*

Cylinder Description ……...*(Family of cylinders which has received type approval)*……..……..

Manufacturer's drawing No: ……

Design life……..… Special torque……..……. Pressure Relief Device…….……

Finished cylinder		**Adhesive**		**Composite materials**	
Capacity	Litres	Material components		Fibre(s)	
Test Pressure	Bar	Viscosity		Fibre(s) tensile Strength	MPa
Diameter	mm	Shear strength	MPa	Fibre(s) modulus	GPa
Length	mm	Glass transition temperature	°C	Matrix components	
Thread		Auto-ignition temperature	°C	Shear strength	MPa
				Tensile strength	MPa
				Tensile modulus	MPa
				Elongation	%
				Min. thickness	mm

Metal End Boss			
Material	Min. yield stress	Min. tensile strength	Elongation
	MPa	MPa	%

Compatible gases……

Manufacturer or agent.....*(Name and address of manufacturer or its agent*) ……

……

……

Type approval mark……

Details of the results of the examination of the design for type approval are detailed in

Report ……..

All information may be obtained from.....*(Name and address of the approving body)* ……

……

……

Date ..... Place ……

Signature ……

B.4 Design variant approval certificate - composite cylinders with metallic liners

Issued by .....*(Relevant authority)*.....on the basis of applying ADR ……..*(date)* and EN 14427, *LPG equipment and accessories - Transportable refillable composite cylinders for LPG — Design and construction*

Approval No° …… Date ……

Approval Expires on ……..*(the date of expiry of the type approval)*

Cylinder description .....*(Cylinder which has received design variant approval)* ……

Manufacturer's drawing No: ……

Original type approval N °……Date ……

Cylinder description ……...*(Cylinder which had received design approval)* ……

Design life……..…….…… Special torque……. Pressure Relief Device…….…..

Liner heat treatment details ……

Finished Cylinder		**Liner**		**Composite material**	
Capacity	litres	Material		Fibre(s)	
Test pressure	bar	Min. thickness	mm	Fibre(s) tensile Strength	MPa
Diameter	mm	Min. yield stress	MPa	Fibre(s) modulus	GPa
Length	mm	Min. tensile strength	MPa	Matrix components	
Thread		Elongation	%	Shear strength	MPa
Autofrettage pressure	bar	Min. burst pressure	bar	Thickness	mm

Compatible gases: ……

Manufacturer or agent.....*(Name and address of manufacturer or its agent)* ……

……

……

Design variant approval mark ……

Details of the results of the examination of the design for design variant approval are detailed in

Report ……

All information may be obtained from.....*(Name and address of the approving body)* ……

……

……

……

Date …… Place ……

Signature ……

B.5 Production test certificate

Inspection body ……

Inspection body's mark ……

Certificate No. ……Cylinders manufactured by…… Date …….

Country…… Mark ……

Specification: EN 14427 ……. Type approval or design variant No ……

Description of cylinders ……

Water capacity……Test Pressure……Design Life ……

Additional design requirements ……

Quantity …..… Manufacturer's part no. ……..Serial numbers ……to ……..

Date of hydraulic pressure test ……

Customer ……Name and address……

Manufacturing batch no. ……

Each cylinder was manufactured in accordance with the requirements of EN 14427 and the design defined in type approval or design variant approval……

All the materials used in the manufacture of the cylinders were identified by individual batch numbers and their properties were verified for compliance with the specification and approved design requirements.

The following materials were used in the manufacture of these cylinders (test reports and material certificates may be attached):

Liner – Material designation					
Supplier	Batch No:	Cylinder serial numbers	Yield Stress MPa	Tensile Strength MPa	Elongation %

Fibres				
Supplier	Fibre Type	Batch No:	Tensile Strength MPa	Shear Strength MPa

Resin system components					
Resin and designation		Curing Agent and Designation		Accelerator and designation	
Supplier	Batch No:	Supplier	Batch No:	Supplier	Batch No:

Finished cylinder			**Batch No:**
Serial No:	Test pressure	No: of cycles	Cycle frequency
Serial No:	Min. Burst pressure	Actual burst pressure	Mode of failure

Pressure test results		
Manufacturer's part no:	Design test pressure	Autofrettage pressure

		Weight kg			Autofrettage expansions cm^3			Pressure test expansions			
Batch No:	Serial No:	Liner	Comp	Total	Volume litres	Total	Perm	Total - T	Perm - P	Elastic	P/T %

I, the undersigned hereby declare that I have checked that the requirements of Table A.1, Table A.2, Table A.3 and Table A.4 of EN 14427 have been met.

Special remarks ……

……

General remarks ……

……

Certified on (date) …… Place……

Signature of the inspector ……

On behalf of…… (Inspection body) ……

Annex C
(informative)

Environmental checklist

Environmental Aspect	Stages of the life cycle										All stages
	Acquisition		Production		Use			End-of-Life			
	Raw materials and energy	Pre-manufactured materials and components	Production	Packaging	Use	Maintenance and repair	Use of additional products	Reuse / Material and Energy Recovery	Incineration without energy recovery	Deposition	Transportation
Inputs											
Materials	4.1	4.1	4.1			4.1	4.1	4.1			4.1
Water		5.1 A.1	5.2.4								
Energy	4.1	4.1	4.1 5.2.8 5.2.12 5.2.13								4.1
Land											
Outputs											
Emissions to air			4.1					5.2.4 5.2.7 5.2.15			
Discharges to water			5.1 A.1					5.2.3.1 5.2.4 5.2.5 5.2.6 5.2.7 5.2.8 5.2.12			
Discharges to soil											
Waste			4.1 5.1 A.1				5.1	5.2.1.1 5.2.1.2 5.2.2.1.1 5.2.2.1.2 5.2.3.1 5.2.4 5.2.5 5.2.6 5.2.7 5.2.8			

								5.2.9 5.2.10 5.2.11 5.2.12 5.2.13 5.2.14 5.2.15 5.2.16 5.2.17 5.2.18 5.3.2			
Noise, vibration, radiation, heat losses								5.2.8 5.2.12 5.2.13			
Other relevant aspects											
Risk to the environment from accidents or unintended use			Intro		4.1.3						
Customer information					4.1						4.1
Comments:											

Bibliography

[1] EN 3-7, *Portable fire extinguishers - Part 7: Characteristics, performance requirements and test methods*

[2] EN 13953, *LPG equipment and accessories - Pressure relief valves for transportable refillable cylinders for Liquefied Petroleum Gas (LPG)*

[3] EN ISO 7866, *Gas cylinders - Refillable seamless aluminium alloy gas cylinders – Design, construction and testing (ISO 7866)*

[4] EN ISO 11363-1, *Gas cylinders - 17E and 25E taper threads for connection of valves to gas cylinders - Part 1: Specifications (ISO 11363-1)*

[5] EN ISO 11363-2, *Gas cylinders - 17E and 25E taper threads for connection of valves to gas cylinders - Part 2: Inspection gauges (ISO 11363-2)*

[6] EN ISO 11439, *Gas cylinders - High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles (ISO 11439)*

[7] EN ISO 14021, *Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling) (ISO 14021)*

[8] EN ISO 14024, *Environmental labels and declarations - Type I environmental labelling - Principles and procedures (ISO 14024)*

[9] EN ISO 14025, *Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025)*

[10] CGA C14, *Procedures for testing of DOT cylinder pressure relief device systems*

[11] European Agreement concerning the International Carriage of Dangerous goods by Road (ADR), Geneva, 30 September 1957, as amended

[12] Regulations concerning the International Carriage of Dangerous Goods by Rail (RID), appearing as Appendix C to the Convention concerning International Carriage by Rail (COTIF), Vilnius, 3 June 1999, as amended

[13] Directive 2010/35/EU of the European Parliament and of the Council of 16 June 2010 on transportable pressure equipment

[14] Measurement uncertainty leaflet (SP INFO 2000 27 uncertainty), Magnus Holmgren et al published by Swedish National Testing and Research Institute

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