BRITISH STANDARD

BS EN
12257:2002

Transportable gas cylinders — Seamless, hoop-wrapped composite cylinders

The European Standard EN 12257:2002 has the status of a British Standard

ICS 23.020.30

National foreword

This British Standard is the official English language version of EN 12257:2002.

The UK participation in its preparation was entrusted by Technical Committee PVE/3, Gas containers, to Subcommittee PVE/3/3, Transportable gas cylinders — Cylinder design, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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EUROPEAN STANDARD

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EN 12257

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English version

Transportable gas cylinders - Seamless, hoop-wrapped composite cylinders

Bouteilles à gaz transportables - Bouteilles sans soudure, frettées composites

Ortsbewegliche Gasflaschen - Nahtlose umfangsgewickelte Flaschen aus Verbundwerkstoffen

This European Standard was approved by CEN on 9 November 2001.

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 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 Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This document EN 12257:2002 has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI.

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 August 2002, and conflicting national standards shall be withdrawn at the latest by August 2002.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the objectives of the framework Directives on Transport of Dangerous Goods.

This European Standard has been submitted for reference into the RID and/or the technical annexes of the ADR. Therefore in this context the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or the technical annexes of the ADR.

Annex A is normative and annex B is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The purpose of this standard is to provide a specification for the design, manufacture, inspection and testing of refillable transportable seamless, hoop wrapped composite cylinders.

The specifications given are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and control during manufacture of cylinders in common use in the countries of the CEN members.

1 Scope

This European Standard specifies minimum requirements for the materials, design, construction, prototype testing and routine manufacturing inspections of composite gas cylinders with a water capacity up to and including 450 litres for compressed, liquefied and dissolved gases.

NOTE For the purposes of this standard, the word “cylinder” includes tubes up to 450 litres water capacity.

This standard is applicable to cylinders that comprise a seamless metal liner reinforced over a substantial part of the parallel length by wound composite fibres of glass, carbon, aramid, or wire.

This standard is not applicable to gas cylinders which are almost totally covered with fibres and commonly called "fully-wrapped" cylinders. For fully-wrapped composite cylinders see EN 12245.

NOTE The specification does not address the design, fitting and performance of removable protective sleeves. Where these are fitted they should be considered separately.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate place in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1089-1, *Transportable gas cylinders— Gas cylinder identification (excluding LPG) – Part 1: Stampmarking.*

EN 1964-1, *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 1: Cylinders made of seamless steel with an R_m value of less than 1 100 MPa.*

prEN 1964-2, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders from 0,5 litres up to and including 150 litres — Part 2: Tensile strength (R_m max) $\geq$ 1 100 MPa.*

EN 1964-3, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of capacity from 0,5 litres up to 150 litres — Part 3: Stainless steel cylinders.*

EN 1975, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless aluminium and aluminium alloy gas cylinders of capacity from 0,5 l up to 150 l.*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test (at ambient temperature)*

EN ISO 11114-1, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic Materials (ISO 11114-1:1997).*

EN ISO 11120, *Gas Cylinders — Refillable seamless steel tubes of water capacity between 150 l and 3000 l — Design, construction and testing (ISO 11120:1999).*

EN ISO 13341, *Transportable gas cylinders — Fitting of valves to gas cylinders (ISO 13341:1997).*

ASTM D 2290-92, *Test method for apparent tensile strength of ring or tubular plastics and reinforced plastics by split disk method.*

ASTM D 2291-83, *Fabrication of ring test specimens for glass-resin composites.*

ASTM D 2343-95, *Test method for tensile properties of glass fibre strands, yarns and rovings used in reinforced plastics.*

ASTM D 4018-93, *Test methods for tensile properties of continuous filament carbon and graphite fiber tows.*

3 Terms, definitions and symbols

For the purposes of this European Standard, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1
ambient temperature
temperature of surroundings varying between 10 °C and 35 °C (for test purposes only)

3.1.2
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 internally when at zero internal gauge pressure

3.1.3
batch, (of fibres, wires or components of the resin system)
homogeneous quantity of material, identified and certified as such by the supplier

3.1.4
batch, (of 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

3.1.5
batch, (of finished cylinders with liners)
quantity of up to 200 finished cylinders plus finished cylinders required for destructive testing, of the same nominal diameter, thickness, length and design. The batch may contain different batches of liners (providing the batches are nominally the same and have had the same treatments), fibres and matrix materials

3.1.6
burst pressure
highest pressure reached in a cylinder or liner during the relevant burst test

3.1.7
composite overwrap
fibres and matrix taken together as a combined unit, or wire reinforcement

3.1.8
exterior coating
layer of clear or pigmented material applied to the cylinder for protection or for cosmetic purposes

3.1.9
fibre or strand
load-carrying part of the composite overwrap e.g. glass, aramid or carbon

3.1.10
hoop-wrapped cylinder
cylinder with composite overwrap along the cylindrical portion of the liner which carries part of the circumferential stress

3.1.11
liner
metallic cylinder that contains the gas and provides a substantial structural strength to the composite cylinder

3.1.12
matrix
material which is used to bind and hold the fibres in place

3.1.13
rejected cylinder
cylinder which in its present condition has not passed the test requirements

3.1.14
wire reinforcement
load carrying overwrap, using a metallic wire (e.g. steel), that does not require a matrix

3.2 Symbols

p_b actual burst pressure of composite cylinder, in bar[1)] above atmospheric pressure

p_{bL} burst pressure of liner, in bar[1)] above atmospheric pressure

p_{bmin} minimum burst pressure of composite cylinder obtained during design variant testing, in bar[1)] above atmospheric pressure

p_h hydraulic test pressure of composite cylinder, in bar[1)] above atmospheric pressure

4 Design and manufacture

4.1 General

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

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

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

  — wire reinforcement.

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

1) 1 bar = 10^5 Pa = 0,1 MPa.

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

4.1.2 Cylinders shall be designed with one or two openings along the central axis only.

4.2 Liner

4.2.1 Liner materials

The liners shall be manufactured in accordance with the relevant sections of the following European standards:

a) seamless steel liners: EN 1964-1 or prEN 1964-2 as appropriate;

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

c) seamless aluminium alloy liners: EN 1975;

d) steel tubes (i.e. >150 l): EN ISO 11120.

The relevant sections are: materials, thermal treatments, neck design, construction and workmanship, mechanical tests.

NOTE This excludes the design requirements, since these are specified by the manufacturer for the design of the composite cylinder. For liners with water capacity above 150 l manufactured of stainless steel or aluminium alloy the relevant sections of the appropriate standard also apply.

The liner material shall be compatible with the gases intended to be used as determined by EN ISO 11114-1.

4.2.2 Design drawing

A fully dimensioned drawing of the liner shall be supplied which includes the specification of the material and material properties. The following material properties shall be specified:

— minimum yield stress;

— minimum tensile strength;

— minimum elongation;

— minimum burst pressure;

— compatibility with the contained gas as determined by EN ISO 11114-1.

4.2.3 Design of ends (heads and bases)

The design of the ends shall be in accordance with the general requirements of the relevant cylinder standard (as identified in 4.2.1). In order to achieve satisfactory stress distribution, the liner wall thickness shall increase progressively in the transition zone between the cylindrical shell and the ends, particularly the base.

The external diameter and thickness of the formed neck end of the liner shall be designed to withstand the torque applied in fitting the valve to the cylinder, and the tests specified in Test No 12 (see 5.2.12) and Test No 13 (see 5.2.13).

4.2.4 Neck ring

When a neck ring is provided, it shall be of a material compatible with that of the cylinder, and shall be securely attached by a method appropriate to the liner material.

4.3 Composite overwrap

4.3.1 Materials

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

4.3.2 Winding

Appropriate procedures shall be defined for the winding and curing process to ensure good repeatability and traceability.

The following parameters shall be defined and monitored:

— percentages of the components of the matrix system and their batch numbers;

— the batch numbers of the fibres or wire used;

— the number of strands used;

— the winding tension per strand or wire, (if applicable);

— the winding speed(s);

— the winding angle and/or pitch for each layer;

— resin bath temperature range, (if applicable);

— the number of layers;

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

— the polymerisation cycle;

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

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

4.4 Finished cylinder

4.4.1 Design drawings

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

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 enclosed with the drawing.

The test pressure, autofrettage pressure (if applicable) and minimum burst pressure for the design shall be specified. The minimum burst pressure shall be at least 1,67 × test pressure (p_h).

Any special characteristics or special limitations (e.g. design life, underwater suitability and/or maximum fitting torque restrictions) shall also be stated.

4.4.2 Autofrettage

Internal pressurisation 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.

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

— autofrettage pressure;

— length of application of this pressure.

If autofrettage is performed, a check shall be made that the procedure has been effectively performed on all cylinders (e.g. through measurement of autofrettage expansions or other equivalent methods).

4.4.3 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).

5 Cylinder and material tests

5.1 General

This clause describes tests to be conducted on seamless, hoop-wrapped composite cylinders, cylinder liners and the materials used in manufacture of cylinders for prototype testing of new cylinder designs, design variant testing and batch acceptance tests. The tests listed may be required or optional, as identified in the schedule of testing and inspections in annex A.

No tests shall be performed with a removable protective sleeve fitted to the cylinder.

5.2 Test procedures and test requirements

5.2.1 Test No 1 - Composite material tests

Procedure:

Tests on the composite materials to establish their mechanical properties shall be carried out in accordance with the following procedures:

a) Tensile properties of fibres:

For glass, aramid: - ASTM D 2290-92 and ASTM 2291-83;

- ASTM D 2343-95;

For carbon: - ASTM D 4018-93.

b) Tensile properties of wires: - EN 10002-1

Equivalent tests in accordance with alternative standards or test specifications acceptable to the inspection body may be applied.

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

Procedure:

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

a) Seamless steel - as described in EN 1964-1, prEN 1964-2, or EN ISO 11120, as appropriate;

b) Seamless stainless steel - as described in EN 1964-3;

c) Seamless aluminium - as described in EN 1975.

Criteria:

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

5.2.3 Test No 3 - Liner burst test at ambient temperature

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 in ambient conditions 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/s 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.

Criteria:

— burst pressure of the liner (p_{bl}) shall be greater than or equal to 0,85 times test pressure (p_h) and to the minimum specified in 4.2.2;

— burst initiation shall be in the cylindrical part and the liner shall remain in one piece.

Parameters to monitor and record:

— burst pressure;

— the number of pieces;

— description of failure;

— pressure/time curve or pressure/volume curve.

5.2.4 Test No 4 - Hydraulic (proof) test of finished cylinders at ambient temperature

Procedure:

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

The water pressure in the cylinder shall increase at a controlled rate until the test pressure (p_h) is reached. The cylinder shall remain at the test pressure (p_h) for at least 30 s.

The limit deviation on attaining test pressure shall be test pressure $^{+3\%}_{0}$ (p_h).

Criteria:

— pressure shall remain steady;

— there shall be no leaks;

— after the test the cylinder shall show no visible permanent deformation.

Parameters to monitor during the test:

— pressure.

5.2.5 Test No 5 – Cylinder burst test at ambient temperature

Procedure:

The hydraulic pressure 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 in ambient conditions and the temperature on the external surface of the cylinder shall be maintained at less than 50 °C. The rate of pressurisation shall not exceed 10 bar /s and the duration of the test shall be at least 40 s.

The cylinder shall be pressurised 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.

Criteria:

— burst pressure shall be greater than or equal to the manufacturer's minimum specified design burst pressure and 1,67 × test pressure ($p_b \geq 1{,}67\ p_h$);

— burst initiation shall be by longitudinal failure in the cylindrical part and the liner shall remain in one piece.

Parameters to monitor and record:

— burst pressure;

— the number of pieces;

— description of failure;

— pressure/time curve or pressure/volume curve.

5.2.6 Test No 6 - Resistance to pressure cycles at test pressure (p_h) and ambient temperature

a) For non-limited life

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 suspend 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 equal to the hydraulic test pressure (p_h). The value of the lower cyclic pressure shall not exceed 10 % of the upper cyclic pressure and shall have an absolute maximum of 30 bar.

The cylinder shall actually experience the maximum and minimum cyclic pressures during this test.

The cycle tests shall be carried out in 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 0,25 Hz (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.

Criteria:

— the cylinder shall withstand 12 000 cycles to test pressure (p_h) without failure by burst or leakage.

Parameters to monitor and record:

— the temperature of the cylinder;

— number of cycles achieving upper cyclic pressure;

— minimum and maximum cyclic pressures;

— cycle frequency;

— test medium used;

— mode of failure, if appropriate.

b) For limited life:

Procedure:

This test shall be conducted in accordance with the procedure as described in a) above and shall consist of two parts run sequentially and continuously. Different criteria apply to the two parts, as shown in Figure 1.

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

Criteria:

— the cylinder shall first withstand N cycles to test pressure (p_h) without failure by burst or leakage, where:

$$N = y \cdot 250$$

where

y is the number of years of design service life, and shall be a whole number greater than 10;

— the test shall continue for a further N cycles, or until failure by leakage whichever is the sooner. In either case the cylinder shall be deemed to have passed the test. However should failure during this second half of the test be by burst, then the cylinder shall have failed Test No. 6.

	1st part	2nd part
Number of cycles	0 ‹----------› N	N ‹----------› $2N$
Criteria	No leakage/burst = Pass	
	No leakage or burst Pass 1st part	Leakage = Pass Burst = Fail

Figure 1 — Criteria for Test No 6

Parameters to monitor and record:

— the temperature of the cylinder;

— number of cycles, achieving upper cyclic pressure;

— minimum and maximum cyclic pressures;

— cycle frequency;

— test medium used;

— mode of failure, if appropriate.

5.2.7 Test No 7 - Immersion in salt water

This test is required for all cylinder designs intended for diving and is optional for other applications.

Procedure:

The cylinder shall be finished as for the intended application and without external coating unless this is an integral part of the design.

Two closed cylinders shall be immersed in an aqueous solution containing 35 g/l of sodium chloride at (20 ± 5) °C for 90 days continuously.

The cylinders shall be immersed:

— for 45 days at not less than 2/3 test pressure (p_h);

— for 45 days without pressure.

The pressure shall be recorded at least at the beginning of the test and after 45 days, prior to de-pressurisation.

Then, following the 90 day immersion:

— 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);

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

Criteria:

— for the first cylinder, burst pressure shall be greater than or equal to 1,67 × test pressure ($p_b \geq 1{,}67\ p_h$), burst initiation shall be by longitudinal failure in the cylindrical part and the liner shall remain in one piece;

— for the second cylinder, criteria shall be as for Test No. 6 (see 5.2.6), as appropriate for the design life.

Parameters to monitor and record:

— the temperature of the solution, at least twice a day;

— filling pressure;

— duration of immersion;

— parameters specified in Test No 5 (see 5.2.5);

— parameters specified in Test No 6 (see 5.2.6).

5.2.8 Test No 8 - Exposure to elevated temperature at test pressure

This test is not required for cylinders wound with wire.

Procedure:

For a design service life of up to 20 years, one cylinder shall be hydraulically pressurised to test pressure (p_h), and shall be maintained at this pressure for 1 000 h.

For a design service life of greater than 20 years, including non-limited life, the test shall run for 2 000 h.

The test shall be conducted at (70 ± 5) °C and a relative humidity of less than 50 %. After this test, the cylinder shall be subjected to Test No 5 (see 5.2.5).

Criteria:

— burst pressure shall be greater than or equal to 1,67 × test pressure ($p_b \geq 1{,}67\ p_h$), burst initiation shall be by longitudinal failure in the cylindrical part and the liner shall remain in one piece;

Parameters to monitor and record:

— measurement of the water capacity before and after test;

— temperature and relative humidity, at least twice a day;

— cylinder pressure at least twice a day;

— parameters specified in Test No 5 (see 5.2.5).

5.2.9 Test No 9 - Extreme temperature cycle test

a) Pressure cycling stages

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 temperature. 5 000 cycles shall be applied from a pressure approximately equal to atmospheric pressure to two-thirds of the test pressure (p_h). 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 0,08 Hz (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 stabilised at ambient conditions.

The temperature shall then be reduced and the cylinder and the contained pressurising medium stabilised at a temperature between minus 50 °C and minus 60 °C. The environmental chamber shall be maintained at the specified conditions by regulating the temperature. The cylinder skin temperature shall be measured and recorded.

The hydraulic pressurising medium, located in the circuit external to the cylinder under test, shall commence the second stage of cycle testing at ambient temperature. 5 000 cycles shall

be applied from a pressure approximately equal to atmospheric pressure to two-thirds of the test pressure (p_h).

On completion of these cycles the pressure shall be released and the cylinder stabilised at ambient conditions. 30 cycles shall then be applied from a pressure approximately equal to atmospheric pressure to test pressure (p_h).

Parameters to monitor and record:

— temperatures during each part;

— humidity during 1st part of test;

— test medium used;

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

— minimum and maximum cyclic pressures;

— cycle frequency.

b) Concluding burst test

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

Criteria:

— burst pressure shall be greater than or equal to 1,4 × test pressure ($p_b \geq 1{,}4\ p_h$)

Parameters to monitor and record:

— burst pressure;

— description of failure.

5.2.10 Test No 10 - Fire resistance test

This test is required for cylinders when a pressure relief device is fitted to prevent failure in a fire during service and is otherwise optional.

Procedure:

Two cylinders shall undergo this test;

— one in a horizontal position;

— one in a vertical position.

The cylinders shall be fitted either:

a) with a valve with the type of pressure relief device intended for service (e.g. fusible plug or bursting disc); or

b) with a valve fitted with a bursting disc set to operate at between test pressure (p_h) and 1,15 p_h.

If the valve in a) is fitted with a fusible plug this shall operate at a minimum temperature of 100 °C.

The cylinders shall be pressurized with either air or nitrogen to 2/3 × test pressure (p_h).

A suitable fire shall be created with either wood or kerosene. Examples of standards that contain directions to produce a suitable fire test are EN ISO 11439, CGA C14:1992 and EN 3-1.

One cylinder shall be placed in the horizontal position with the lowest part of the cylinder approximately 0,1 m from the top of the firewood or 0,1 m from the surface of the liquid. The fire shall be capable of enveloping the entire length of the cylinder and valve, but in no case shall the flames be allowed to impinge directly on to the pressure relief device.

The second cylinder shall be placed in an upright position (valve uppermost), with the lowest part of the cylinder approximately 0,1 m from the top of the firewood or at the surface of the liquid. The cylinder shall be exposed to total fire engulfment, but in no case shall the flames be allowed to impinge directly on to the pressure relief device.

If the cylinder is too long to enable the fire to envelop the entire length of the cylinder when in the vertical position, and the cylinder does not have pressure relief devices at both ends, the vertical bonfire test may be replaced by a second test in the horizontal position.

The test is considered complete when all the gas inside the cylinder has vented completely or when a period of two minutes has elapsed.

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

Criteria:

The cylinders shall not burst during a period of 2 min from the start of the fire test. They may vent through the pressure relief device or leak through the cylinder wall or other surfaces.

Parameters to monitor and record:

— type and characteristics of pressure relief device;

— initial pressure;

— time;

— mode of pressure release, if appropriate.

5.2.11 Test No 11 - High velocity impact (bullet) test

This test is optional (e.g. for military applications).

Procedure:

For cylinders with diameter above 120 mm a cylinder pressurized with air or nitrogen to 2/3 × test pressure (p_h) shall be impacted by a 7,62 mm (0,3 calibre) armour-piercing projectile of nominal length 51 mm and having a velocity of approximately 850 m/s. The cylinder shall be positioned in such a way that the point of impact of the projectile shall be in the sidewall (i.e. the area with circumferential winding) and shot at an angle of approximately 45° to the centre line of the cylinder, so that it would exit through the cylinder sidewall. The distance from firing location to test cylinder shall not exceed 45 m.

For cylinders with a diameter of 120 mm and below, a 5,6 mm (0,22 calibre) projectile of 13,6 mm nominal length may be used.

Criteria:

— the tested cylinder shall reveal no evidence of a fragmentation failure, whether or not the bullet penetrates the cylinder.

Parameters to monitor and record:

— type of projectile;

— initial pressure;

— description of failure;

— approximate size of the entrance and exit openings.

5.2.12 Test No 12 - Torque test

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 13341, or as recommended in the manufacturer's specification where this 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 For example, where the neck thread is specified to be in accordance with EN 629-1, the corresponding gauges are specified in EN 629-2.

Criteria:

— the threads shall remain within gauge tolerance.

Parameters to monitor and record:

— type of valve/plug material;

— valving procedure;

— applied torque.

Where the torque recommended by the manufacturer differs from that specified in EN ISO 13341, this shall be recorded on the label (see clause 7).

5.2.13 Test No 13 - Neck strength

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 procedures specified in EN ISO 13341, or as recommended in the manufacturer's specification where this standard does not apply.

Criteria:

— the neck shall show no significant deformation.

Parameters to monitor and record:

— type of valve/plug material;

— valving procedure;

— applied torque.

Where the torque recommended by the manufacturer differs from that specified in EN ISO 13341, this shall be recorded on the label (see clause 7).

5.2.14 Test No 14 - Cylinder stability

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

5.2.15 Test No 15 - Neck ring

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

5.3 Failure to meet test requirements

5.3.1 Liner

Where the mechanical properties of the liner have not met the specification requirements, 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

For complete cylinders the following procedure may be used for prototype testing, design variant testing and production testing.

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

— if 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 if possible. If the results of this test are satisfactory, the first test shall be ignored;

— if 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 for the intended purpose. If the cause of failure is identified the defective cylinders may be reclaimed by an approved method or shall be rendered unserviceable for the intended purpose. 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 or batches covered by the test shall be rendered unserviceable for the intended application.

6 Conformity evaluation

Prototype testing, design variant testing and production testing shall be carried out in accordance with annex A.

7 Marking

The permanent markings, including the stamping, shall be in accordance with EN 1089-1.

Specific additional information shall be included on the label as follows:

— where a cylinder is approved with a specific pressure relief device, intended to prevent failure in the case of fire (Test No 10, see 5.2.10), this requirement shall be stated and the type of device shall be identified on the label;

— where the fitting torque for the valve does not correspond to the values given in EN ISO 13341, the manufacturer's recommendation shall be shown on the label;

— where the cylinder has been approved for special applications this shall be shown on the label e.g. underwater.

Annex A
(normative)

Prototype testing, design variant testing and production testing

A.1 General

This annex describes the schedules of tests to be carried out on hoop wrapped composite cylinders as required 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 testing).

Testing shall be carried for each new design or design variant of cylinder (see A.2. and A.3).

A.2 Prototype testing

A.2.1 General

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

Prototype testing 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).

The prototype testing 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.

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:

a) It is manufactured in a different factory. However, where a factory moves to a different location with the same equipment, a reduced testing programme may be agreed with the inspection body;

b) It is manufactured by a significantly different process. A significant change is regarded as a change that would have a measurable change in the performance of the liner and/or finished cylinder. The inspection body shall determine when a change in process or design or manufacture is significantly different from the original prototype tested design;

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, as listed in 4.2.1;

d) It is manufactured with a new fibre type.

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;

e) It is manufactured using different matrix materials e.g. resin, curing agent, accelerator (see Note 1);

f) The hydraulic test pressure has been increased by more than 60 % (see Note 2);

g) The nominal cylinder diameter has changed by more than 50 %;

h) The nominal autofrettage pressure has changed by more than 5 %.

NOTE 1 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.

NOTE 2 A cylinder can be used and marked for a lower test pressure than stated in the original prototype testing without additional testing.

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 to the inspection body a batch of at least 50 cylinders from which the number of cylinders required for the tests referred to below will be taken. 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, the inspection body shall:

a) select the necessary cylinders for testing in accordance with the Tables A.1, A.2 and A.3, as applicable;

b) verify that:

1) the design conforms to the requirements of clause 4;

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

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

c) witness or carry out the tests as stipulated in the Tables A.1, A.2 and A.3, as applicable.

A.2.4 Prototype testing certificate

If the results of the prototype testing are satisfactory, the inspection body shall issue a prototype testing certificate to the manufacturer. This protoype testing certificate may take the form of a type approval certificate, a typical example of which is given in annex B.

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

Table A.1 — Composite materials

Test	Prototype testing and design variant testing	Production testing
Test No 1a - Tensile properties of fibres	2 tests	1 test per batch of fibres
Test No 1b - Tensile properties of wire	2 tests	1 test per batch of wire

Table A.2 — Liner tests

Test	Prototype testing and design variant testing [b]	Production testing [b]
Test No 2 - Liner material tests to the appropriate standard [a]	Quantity prescribed by appropriate standard	-
Test No 2 - Liner material tests to the appropriate standard [a] mechanical properties only	-	1 per liner batch
Test No 3 - Liner burst test	1	-
Homogeneity (e.g. hardness, electrical conductivity)	100 %	100 %
Visual inspection	100 %	10 %
Dimensional check	100 %	10 %

[a] For list of appropriate standards see 5.2.2.

[b] The numbers in the table represent the number of liners that shall be subjected to the relevant test.

Table A.3 — Tests on finished cylinders

Test	Prototype testing and design variant testing [f]	Production testing [f]
Visual inspection	100 %	10 % [e]
Dimensional check	100 %	10 % [e]
Weight check	100 %	10 % [e]
Water capacity	100 %	10 % [e]
Marking compliance	100 %	100 %
Test No 4 - Hydraulic (proof) test	100 %	100 %
Test No 5 - Hydraulic pressure burst test [a]	3	1 per batch
Test No 6 - Pressure cycling test [a]	2	Minimum of 1 per 5 batches
Test No 7 - Salt-water immersion test [b]	2	-
Test No 8 - Exposure to elevated temperature at test pressure test	2	-
Test No 9 - Extreme temperature cycle test	1	-
Test No 10 - Fire resistance test [c]	2	-
Test No 11 - High velocity impact test [d]	1	-
Test No 12 - Torque test	1	-
Test No 13 - Neck strength test	1	-
Test No 14 - Stability test (if applicable)	1	-
Test No 15 - Neck ring test (if applicable)	1	-

[a] For cylinders greater than 150 litres water capacity, a smaller cylinder with the same diameter, thickness and wrap pattern may be used for production testing. The comparability of burst and cycle performance shall first be demonstrated before the smaller capacity cylinder may be used.

[b] Test No 7 is optional except for diving applications where it is required.

[c] Only necessary where a pressure relief device is fitted to prevent failure in a fire during service.

[d] Optional e.g. for military applications.

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

[f] The numbers in the table represent the number of cylinders that shall be subjected to the relevant test.

A.3 Design variant testing

A.3.1 General

For cylinders within the definition of a design variant when compared with a prototype tested design, a reduced testing programme may be carried out. Design variant testing shall be conducted for each design variant of 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); or

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

c) the cylinder conforms to the conditions in A.3.2.4.

A.3.2.2 Equivalent fibre

For a fibre or wire having similar nominal mechanical and physical characteristics to the prototype tested fibre or wire, its equivalency shall be verified as follows before the fibre or wire can be considered as a design variant.

The new fibre with the existing prototype tested resin system or wire shall be subjected to the 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 or wire.

NOTE Where a new equivalent fibre or wire 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 or wire without the need for any additional prototype testing.

A.3.2.3 Equivalent liner

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

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

b) the liner is of the prototype tested design except that it is manufactured using a significantly different process from that used to produce the prototype tested design;

c) the liner is of the prototype tested design except that it is given a heat treatment outside the limits specified in the prototype tested design.

The new 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.

NOTE 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.3.2.4 Cylinder variant

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 nominal length of the cylinder has changed to below 2 × diameter or has increased by more than 50 % of the prototype tested design length;

b) the nominal outside diameter has changed by less than or equal to 50 % (see Note);

c) the hydraulic test pressure has changed by less than or equal to 60 %;

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

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

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

g) the liner 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.

NOTE Where the change in nominal diameter is less than or equal to 20 %, a different test regime is applicable compared to that for changes between 20 % and 50 % (see Table A.4).

The inspection body shall determine the level of testing required and may request other tests than those specified to carry out design variant testing, where it is considered necessary or for special applications.

A.3.3 Design variant test requirements

For each design of cylinder variant the applicant for design variant testing shall submit the documentation necessary for the checks specified below. The applicant shall also make available to the inspection body 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.

The applicant shall also submit one or more liners taken at random from the same batch just prior to winding.

In the course of the design variant testing process, the inspection body shall:

a) consider the changes of the design variant against the previously prototype tested cylinder and determine the required level of testing;

b) select the necessary cylinders for testing in accordance with Table A.4;

c) verify that:

— the design conforms to the requirements of clause 4;

— the design is in accordance with the manufacturing drawing;

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

d) witness or carry out the tests as specified in Table A.4.

A.3.4 Design variant testing certificate

If the results of the design variant testing are satisfactory, the inspection body shall issue a design variant testing certificate to the manufacturer. This design variant testing certificate may take the form of a design variant approval certificate, a typical example of which is given in annex B.

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

Table A.4 — Design variant test requirements

Test No	Test	New design	Design variant changes									
			Design test pressure	Nominal length - L		Nominal diameter - D		Liner design or thickness	Composite thickness or wrap pattern	Fibre	Neck thread change	Auto-frettage pressure
			changed by ≤ 60 %	new length < 2D	new length > 1,5 L	changed by ≤ 20 %	changed by > 20 % and < 50 %					
1	Composite material tests	✓							✓ [h]			
2	Liner material tests	✓						✓ [g]				
3	Liner burst	✓	✓		✓	✓	✓	✓				
4	Pressure test	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
5	Burst	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
6	Ambient cycle	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
7	Salt water immersion [a]	✓										
8	Max. temperature	✓	✓ [f]				✓ [f]		✓ [f]			
9	Extreme temperature cycle	✓										
10	Fire resistance [b]	✓										
11	High velocity Impact [c]	✓										
12	Torque test	✓									✓	
13	Neck strength	✓				✓	✓	✓			✓	
14	Stability [d]	✓			✓	✓	✓					
15	Neck ring [e]	✓										

[a] Cylinders for underwater applications only.
[b] Only necessary where pressure relief device is fitted to prevent failure in a fire during service.
[c] Optional e.g. military applications.
[d] Free standing cylinders only.
[e] Cylinders with neck rings fitted only.
[f] Where $p_b$min /p_h ratio for design variant is less than manufacturer's specified p_b/p_h ratio for prototype design, then Test No 8 shall be carried out.
[g] For equivalent liner testing.
[h] 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 inspection body with:

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 drawn up jointly by the manufacturer and supplier, 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 the inspection body shall:

a) ascertain that 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) select the necessary liners for testing in accordance with A.4.3;

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

e) check whether the requirements set out in clause 4 have been met and carry out the inspections in accordance with A.4.5.2;

f) select the necessary cylinders for testing in accordance with A.4.5.1.

A.4.3 Liner batch tests and inspections

The inspections and tests shall be carried out as specified in Table A.2.

The liner shall conform to the design drawing of the prototype and the supply specifications drawn up jointly by the manufacturer and his supplier. The inspections shall include both non-destructive tests, i.e. visual, dimensions, etc., and destructive tests i.e. tensile tests.

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 conform to the design drawing of the prototype and the supply specifications drawn up jointly by the cylinder manufacturer and the material supplier.

A.4.5 Tests and inspections of the finished cylinder

A.4.5.1 Tests

The tests shall be carried out on a batch of finished cylinders as specified in Table A.3, 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;

NOTE It can be instructive to compare the results of the hydraulic burst test, Test No. 5 (see 5.2.5), on the prototype testing cylinders, the design variant testing cylinders and production testing 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 inspection body may wish to determine the cause of the variation.

Similarly, the maximum burst pressure should not be more than 120 % 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.4.5.2 Inspections

The inspections shall be carried out on a batch of finished cylinders as specified in Table A.3, as follows:

a) visual inspection, in accordance with 4.4.3 - 10 % minimum

b) dimensional check - 10 % minimum

c) weight - 10 % minimum

d) water capacity check - 10 % minimum

e) compliance of marking - 100 %

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

A.4.6 Batch acceptance certificate

If the results of the checks and tests are satisfactory, the inspection body shall issue a production testing certificate, a typical example of which is given in annex B.

If 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

Issued by ..... *(Relevant authority)* on the basis of applying EN 12257 — Transportable gas cylinders - Seamless, hoop-wrapped composite cylinders

Approval N° ..... Date .....

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

.....

Manufacturer's drawing No: .....

Design life ..... Underwater ..... Special torque ..... Pressure relief device.....

Liner heat treatment details .....

Finished cylinder		**Liner**		**Composite material**	
Capacity	l	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	%		
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 Qualification Test Report

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

.....

.....

.....

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

Signature .....

B.2 Design variant approval certificate

Issued by .....*(Relevant authority)*..... on the basis of applying EN 12257 - Transportable gas cylinders - Seamless, hoop-wrapped composite cylinders

---

Approval N° ..... Date .....

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 ..... Underwater ..... Special Torque..... Pressure Relief Device .....

Liner Heat Treatment Details .....

Finished cylinder		**Liner**		**Composite material**	
Capacity	l	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 Qualification Test Report .....

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

Signature .....

B.3 Production testing certificate

Inspection body .....

Inspection body's mark .....

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

Country ..... Mark .....

Specification: EN 12257 Type approval or design variant approval 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 & address.....

Manufacturing batch no. .....

Each cylinder was manufactured in accordance with the requirements of EN 12257 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 that they complied with the specification and approved design requirements.

The following materials were used in the manufacture of these cylinders:

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	

Resin System Components					
Resin & Designation		Curing Agent & Designation		Accelerator & 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			Capacities l		Autofrettage Expansions*	
Batch No:	Serial No:	Liner	Comp	Total			Total	Permanent
* Optional see 4.4.2.								

I, the undersigned hereby declare that I have checked that the requirements of Tables A.1, A.2 and A.3 of EN 12257 have been carried out satisfactorily.

Special remarks .....

.....

General remarks .....

.....

Certified on (date) ..... Place.....

Signature of the inspector .....

On behalf of..... *(Inspection body)* .....

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CGA C14:1992, *Procedures for testing of DOT cylinder pressure relief device systems*

Council Directive 1999/36/EC of 29 April 1999 on transportable pressure equipment (TPED)

ADR European agreement on the International Carriage of Dangerous Goods by Road

RID Regulations concerning the International Carriage of Dangerous Goods by Rail

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