BS EN 14140:2014
Incorporating corrigendum May 2015

BSI Standards Publication

LPG equipment and accessories — Transportable refillable welded steel cylinders for LPG — Alternative design and construction

National foreword

This British Standard is the UK implementation of EN 14140:2014 incorporating corrigendum May 2015. It supersedes BS EN 14140:2003 which is withdrawn.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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English Version

LPG equipment and accessories - Transportable refillable welded steel cylinders for LPG - Alternative design and construction

Équipements pour GPL et leurs accessoires - Bouteilles en acier soudé transportables et rechargeables pour gaz de pétrole liquéfié (GPL) - Autres solutions en matière de conception et construction

Flüssiggas-Geräte und Ausrüstungsteile - Ortsbewegliche, wiederbefüllbare, geschweißte Flaschen aus Stahl für Flüssiggas (LPG) - Alternative Gestaltung und Konstruktion

This European Standard was approved by CEN on 9 August 2014.

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Contents

Page

Foreword

This document (EN 14140:2014) 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of an identical text or by endorsement, at the latest by June 2015 and conflicting national standards shall be withdrawn at the latest by June 2015.

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 14140:2003+A1:2006.

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

This European Standard has been submitted for reference into:

- the RID [11]; and
- the technical annexes of the ADR [12].

NOTE These regulations take precedence over any clause of this European Standard. It is emphasised that RID/ADR/ADN are being revised regularly at intervals of two years which may lead to temporary non-compliances with the clauses of this European Standard.

The major changes to this revision include:

- restructure of standard;
- the addition of requirements for hot air balloon cylinders;
- an update on the terminology;
- the addition of requirements for over-moulded cylinders;
- the addition of the environmental checklist, Annex D.

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 may be injurious to health and/or the environment if adequate precautions are not taken. It refers only to technical suitability: it does not absolve the user from their legal obligations 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.

This European Standard permits the use of new and higher strength steels and has the potential for cylinders to have a wall thickness thinner than the minimum wall thickness related to diameter, when compared with cylinders in accordance with EN 1442. These changes in technology are justified by requiring a series of performance tests, including impact testing, to demonstrate the adequacy of the calculated pressure thickness for service and transport considerations

Reference should also be made to EN 1439 and EN 1440, 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.

Protection of the environment is a key political issue in Europe and elsewhere around the world. Protection of the environment in this document is understood in a very broad sense. The phrase is used, for example, in relation to the total life-cycle aspects of a product on the environment, including expenditure of energy, and during all phases of its existence, from mining of raw materials, to fabrication, packaging, distribution, use, scrapping, recycling of materials, etc. Annex D comprises an environmental checklist which highlights the clauses of this European Standard that address environmental aspects.

It is recommended that manufacturers develop an environmental management policy. For guidance see EN ISO 14000 series, [6], [7] and [8]].

Provisions need to be restricted to a general guidance. Limit values are specified in national laws.

All pressures are gauged unless otherwise stated.

NOTE This European 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 the minimum requirements for the design, construction and testing during manufacture of transportable refillable welded steel Liquefied Petroleum Gas (LPG) cylinders, of water capacity from 0,5 l up to and including 150 l, exposed to temperatures of -20 °C to +65 °C. It allows alternative design and construction methods to those required in EN 1442, including coated cylinders, over-moulded cylinders and cylinders for hot air balloons.

This European Standard applies only to pressure receptacles with a circular cross-section.

This European Standard does not include the equipping of the cylinders with valves and other service equipment.

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 10028-7, *Flat products made of steels for pressure purposes - Part 7: Stainless steels*

EN 10120, *Steel sheet and strip for welded gas cylinders*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 10272, *Stainless steel bars for pressure purposes*

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

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

EN ISO 643, *Steels - Micrographic determination of the apparent grain size (ISO 643)*

EN ISO 2409:2013, *Paints and varnishes - Cross-cut test (ISO 2409:2013)*

EN ISO 2812-2, *Paints and varnishes - Determination of resistance to liquids - Part 2: Water immersion method (ISO 2812-2)*

EN ISO 3231:1997, *Paints and varnishes - Determination of resistance to humid atmospheres containing sulfur dioxide (ISO 3231:1993)*

EN ISO 4136, *Destructive tests on welds in metallic materials - Transverse tensile test (ISO 4136)*

EN ISO 4624, *Paints and varnishes - Pull-off test for adhesion (ISO 4624)*

EN ISO 5173, *Destructive tests on welds in metallic materials - Bend tests (ISO 5173)*

EN ISO 6520-1, *Welding and allied processes - Classification of geometric imperfections in metallic materials - Part 1: Fusion welding (ISO 6520-1)*

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

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

EN ISO 9606-1, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1)*

EN ISO 9712:2012, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

EN ISO 11117:2008, *Gas cylinders - Valve protection caps and valve guards - Design, construction and tests (ISO 11117:2008)*

EN ISO 11997-2, *Paints and varnishes - Determination of resistance to cyclic corrosion conditions - Part 2: Wet (salt fog)/dry/humidity/UV light (ISO 11997-2)*

EN ISO 14732, *Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1)*

EN ISO 15613, *Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test (ISO 15613)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1)*

EN ISO 17636-1:2013, *Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1:2013)*

EN ISO 17636-2:2013, *Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2:2013)*

EN ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637)*

EN ISO 17639, *Destructive tests on welds in metallic materials - Macroscopic and microscopic examination of welds (ISO 17639)*

EN ISO 19232-1, *Non-destructive testing - Image quality of radiographs - Part 1: Determination of the image quality value using wire-type image quality indicators (ISO 19232-1)*

EN ISO 19232-2, *Non-destructive testing - Image quality of radiographs - Part 2: Determination of the image quality value using step/hole-type image quality indicators (ISO 19232-2)*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
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

3.1.2
cylinder
transportable, pressure receptacle with a water capacity not exceeding150 l

3.1.3
over-moulded cylinder
a cylinder intended for the carriage of LPG of a water capacity not exceeding 13 l made of a coated steel inner pressure receptacle with an over-moulded protective case made from cellular plastic which is non removable and bonded to the outer surface of the inner receptacle wall

3.1.4
manufacturer
manufacturer of the cylinder, unless otherwise specified

3.1.5
yield strength
upper yield strength R_{eh} or, for steels that do not exhibit a definite yield, the 0,2 % proof strength $R_p0,2$

3.1.6
heat treatment
solution heat treatment, quenching and artificial or natural ageing that ensures the strength values required

3.1.7
normalised
condition resulting from heat treatment to a uniform temperature above the upper critical point (Ac3) of the steel and then cooled under controlled conditions

3.1.8
stress relieved
condition resulting from heat treatment in which a finished cylinder is heated to a uniform temperature below the lower critical point (Ac1) of the steel and cooled in a still atmosphere, the object of which is to reduce the residual stresses without altering the metallurgical structure of the steel

3.1.9
production batch
group of pressure parts or finished pressure vessels, made consecutively by the same manufacturer using the same manufacturing techniques to the same design, nominal size and material specifications on the same production machinery and subject to the same heat treatment conditions

Note 1 to entry: In this context, 'consecutively' need not imply continuous production.

3.1.10
over-moulded casing
layer of over-moulded material which gives mechanical protection which, either cannot be removed without destroying it or is only removable with special tools or is bonded to the cylinder wall

Note 1 to entry: This definition can be applied to cylinders with over-moulded layers or with separate casings.

3.1.11
protective coating
layer of paint or other material applied to the pressure receptacle to provide resistance to external corrosion

3.1.12
hot air balloon cylinder
stainless steel cylinder, fitted with a removable structural foam protective cover, which has been approved for aviation purposes (Commission Regulation (EU) No 748/2012, Annex Part 21)

3.1.13
cold-forming
forming at temperatures not less than 25 °C below the maximum permissible temperature for stress relieving, in accordance with the applicable material specifications

3.1.14
production batch (over-moulded cylinders)
12 months production of cylinders from a single over-moulding company, using inner cylinders manufactured by one manufacturer

3.2 Symbols

a	Calculated minimum thickness of the cylindrical shell, in millimetres.
A	Percentage elongation after fracture.
b	Calculated minimum thickness of the end of the cylinder, in millimetres.
C	Shape factor for ends (see Table 1 and Figure 2).
D	Outside diameter of the cylinder as given in the design drawing (see Figure 1), in millimetres.
D_p	Outside diameter of a bend tests former (see Figure 8), in millimetres.
e	Actual thickness of the material used, in millimetres.
F	Energy, in Joules, used in the cylinder body impact tests.
h	Height, in millimetres, of the cylindrical part of the end (see Figure 1).
H	Outside height, in millimetres, of the domed part of the end (see Figure 1).
J	Stress reduction factor.
l	Length of the cylinder, in millimetres.
L_O	Original gauge length of the test piece, in accordance with EN ISO 6892-1, in millimetres.
M	Maximum operating mass of the cylinder, in kg.
n	Ratio of diameter of bend test former to the thickness of the test piece, (see Table 5).
P_c	Calculation pressure (1 bar = 10^5 Pa = 10^5 N/m$^{2)}$, used to calculate the minimum required thickness of the cylindrical shell and ends, in bar.
P_b	Maximum pressure attained during the burst test, in bar.
P_h	Actual test pressure applied to the cylinder by the manufacturer, in bar.
P_{hmin}	Minimum permissible test pressure, in bar.
r	Inside knuckle radius of the end, in millimetres.
R	Inside dishing radius of the end, in millimetres.
R_g	Guaranteed tensile strength guaranteed by the cylinder manufacturer for the finished cylinder, in N/mm^2.
R_o	Minimum value of yield strength guaranteed by the cylinder manufacturer for the finished cylinder, in N/mm^2.
R_m	Actual value of tensile strength determined by the tensile test specified in 7.4, in N/mm^2.

4 Materials

4.1 Steels for the pressure receptacle shall not be affected or weakened by the intended contents (LPG) and shall not cause a dangerous effect e.g. catalysing a reaction or reacting with the dangerous goods. The steel shall be resistant to brittle fracture and to stress corrosion cracking.

NOTE See EN ISO 11114-1.

4.2 Materials for shells and end pressings shall be:

a) carbon steel in accordance with EN 10120 or other appropriate standard providing they comply with the tests results described in this European Standard, or

b) stainless steel in accordance with EN 10028-7.

4.3 All parts welded to the cylinder shall be made of material compatible with the cylinder material. For hot air balloon cylinders the valve and fitting bosses shall be stainless steel in accordance with EN 10272.

4.4 Materials used for the coating, protection and over-moulding of cylinders shall conform to the material specifications, which shall be available to the manufacturer and for the type approval.

4.5 The welding consumables shall be such that they are capable of giving consistent welds. The strength characteristics of the welds in the finished cylinder shall fulfil all requirements for the design and calculation of the cylinder.

4.6 The cylinder manufacturer shall obtain certificates showing the chemical analysis and details of the mechanical properties of the steel supplied for the construction of the pressure retaining parts. The certificates shall be in accordance with EN 10204:2004, certificate Type 3.1 for shells and ends and Type 2.2 for the valves and fittings boss or bosses.

4.7 The manufacturer shall maintain a system of identification for the materials used in the fabrication in order that all materials for pressure parts in the completed cylinder can be traced to their origin.

4.8 The manufacturer shall endeavour to acquire materials and components from suppliers who have a declared environmental policy, see EN ISO 14021 [6], EN ISO 14024 [7] and EN ISO 14025 [8].

4.9 The design of cylinders and over-moulded or protective casings shall minimize the waste of materials.

4.10 The manufacturer should endeavour to minimise wastage of material by selecting appropriately sized materials related to the finished parts required for manufacture.

4.11 Over-moulded or protective casings manufactured from recyclable plastic materials shall display the appropriate recycling symbol.

4.12 All processes should be designed to minimise VOC emissions.

5 Design

5.1 General requirements

5.1.1 The calculation of the wall thickness of the pressure parts shall be based on the yield strength of the material.

5.1.2 For calculation purposes, the value of the yield strength R_o is limited to a maximum of 0,85 R_g.

5.1.3 The calculation pressure (P_c) shall be:

a) for cylinders restricted to LPG with a test pressure not exceeding 16 bar absolute (UN1011, UN 1965 Mixtures A, A01, A02 and A0 and UN 1969):

$P_c = P_{hmin}$ = 15 bar.

b) for all other LPG cylinders:

$P_c = P_{hmin}$ = 30 bar.

NOTE See RID/ADR 4.1.4.1 P200 Table 2 for LPG test pressures.

5.1.4 A fully dimensioned drawing including the specification of the material shall be produced.

5.1.5 The design of the cylinder should take into account the following:

- ease of manual handling;
- ease of connection for filling and use;
- safe stacking (when designed to be stacked);
- minimising the use of materials; and
- minimising the environmental impact of in service, maintenance and end of life disposal.

5.2 Calculation of cylindrical shell wall thickness

The wall thickness, *a*, of the cylindrical shell shall be not less than:

$$a = \frac{P_c \times D}{\frac{20 \times R_o \times J}{4/3} + P_c}$$

For cylinders with a longitudinal weld: $J = 0{,}9$

For cylinders without a longitudinal weld: $J = 1{,}0$

5.3 Design of torispherical and semi-ellipsoidal ends concave to pressure

5.3.1 The shape of ends shall be such that the following conditions are fulfilled:

- for torispherical ends $R \leq D$; $r \geq 0{,}1\ D$; $h \geq 4b$ (see Figure 1),
- for semi-ellipsoidal ends $H \geq 0{,}192\ D$; $h \geq 4b$ (see Figure 1).

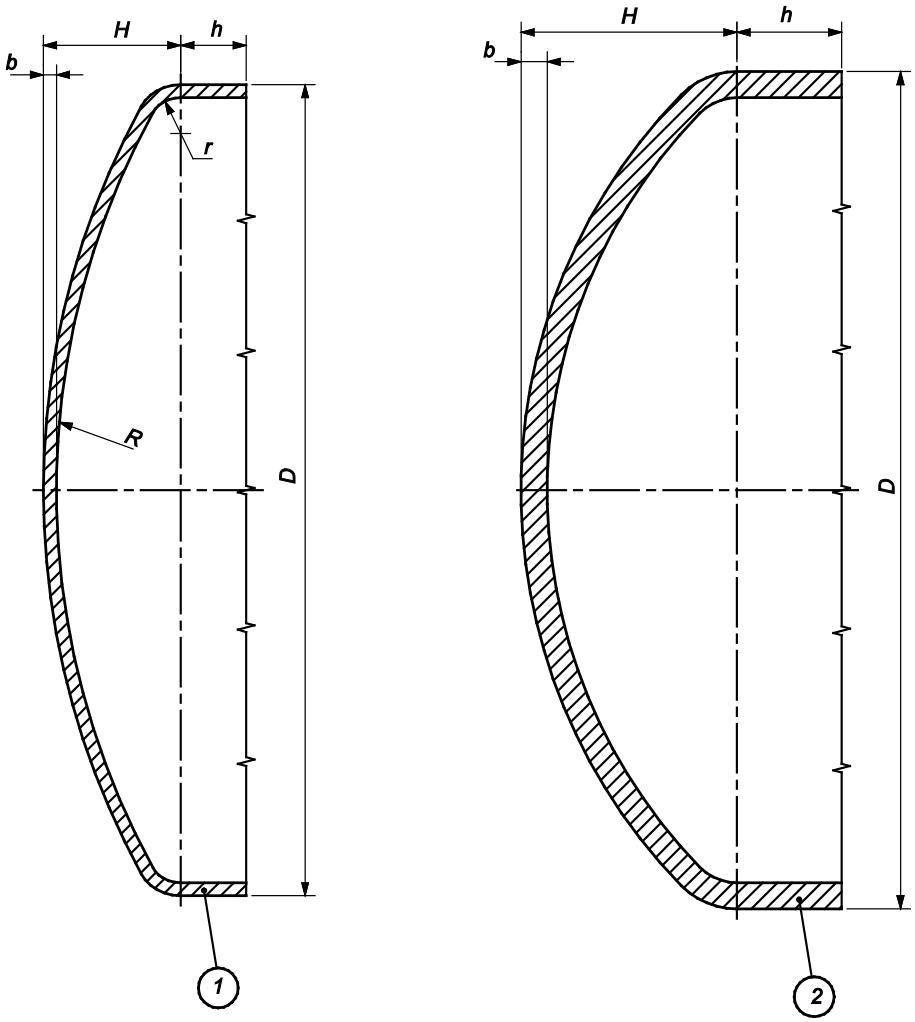
5.3.2 The wall thickness, *b*, shall be not less than:

$$b = \frac{P_c \times D \times C}{(15 \times R_o) + P_c}$$

In this formula, *C* is a shape factor, the value of which depends on the ratio H/D.

For H/D values between 0,2 and 0,25 the value of C shall be obtained from Figure 2.

For H/D values between 0,25 and 0,5 the value of C shall be obtained from Table 1 or Figure 3.



Key

1 torispherical end

2 semi-ellipsoidal end

NOTE For torispherical ends the height *H* can be calculated using:

$$H = (R + b) - \sqrt{[(R + b) - \frac{D}{2}] \times [(R + b) + \frac{D}{2} - 2(r + b)]}$$

Figure 1 — Illustration of cylinder ends concave to pressure

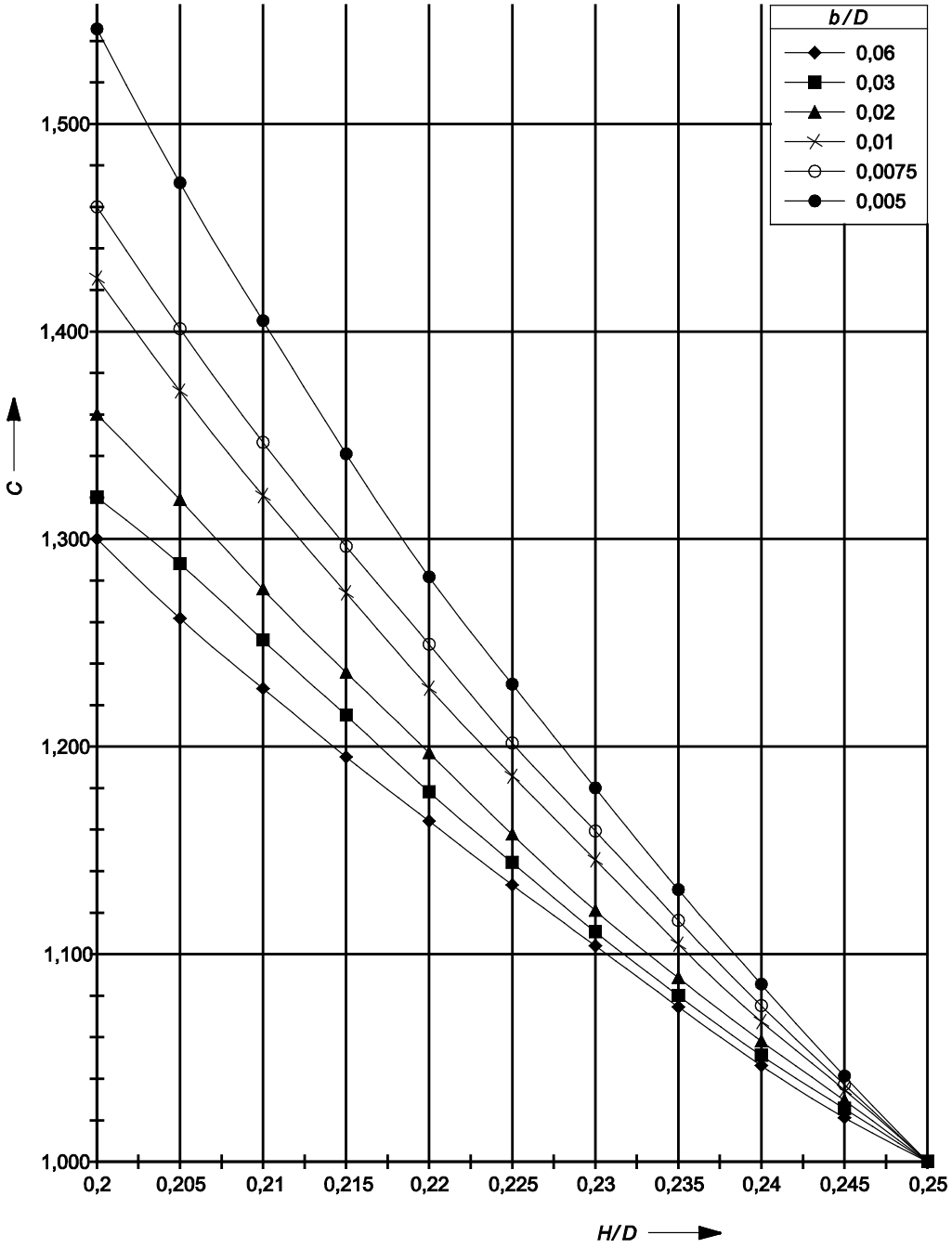


Figure 2 — Values of shape factor *C* for *H/D* between 0,2 and 0,25

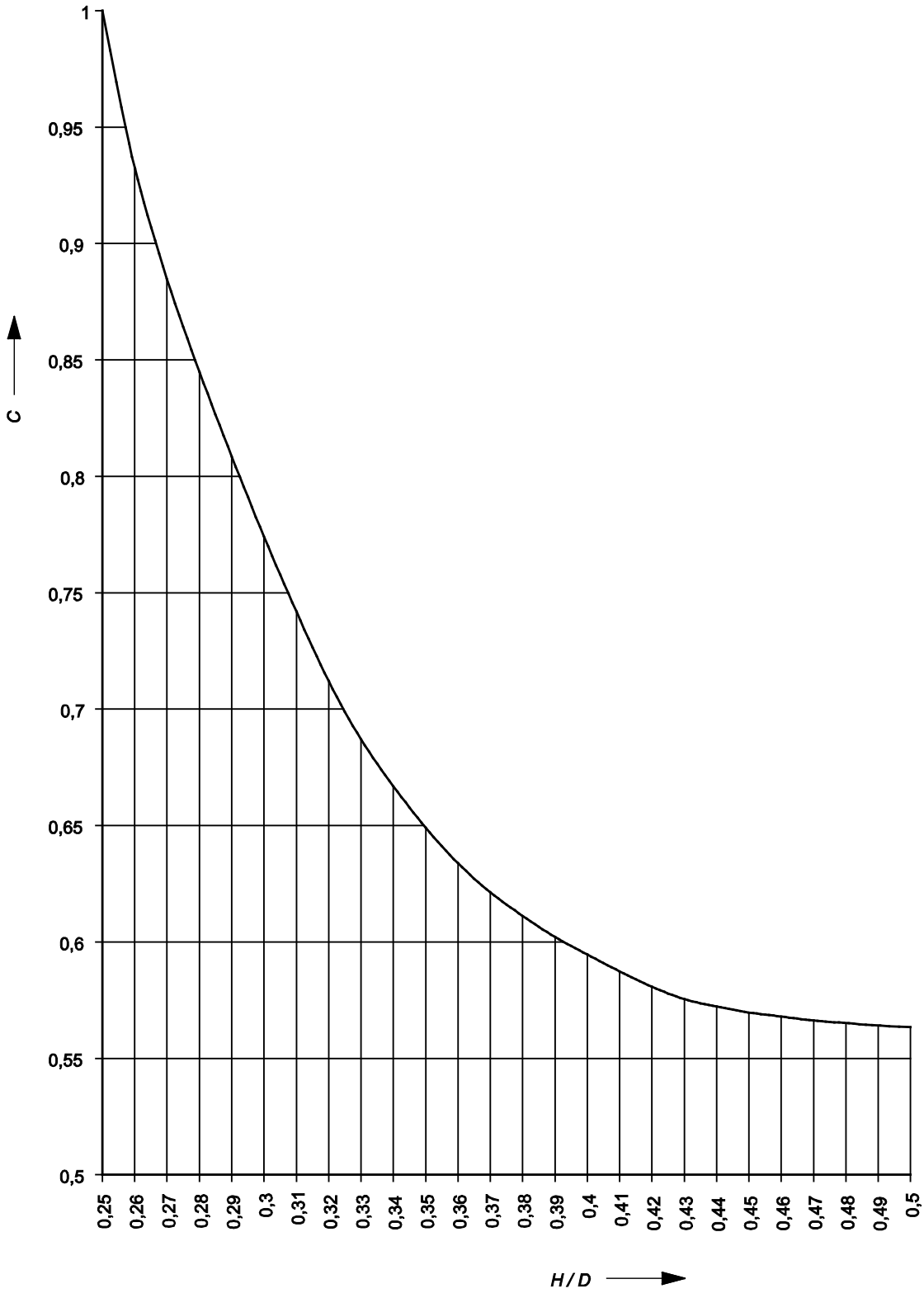


Figure 3 — Values of shape factor *C* for H/D between 0,25 and 0,5

Table 1 — Relationship between *H/D* and shape factor *C*

H/D	*C*		*H/D*	*C*
0,25	1,000		0,38	0,612
0,26	0,931		0,39	0,604
0,27	0,885		0,40	0,596
0,28	0,845		0,41	0,588
0,29	0,809		0,42	0,581
0,30	0,775		0,43	0,576
0,31	0,743		0,44	0,572
0,32	0,713		0,45	0,570
0,33	0,687		0,46	0,568
0,34	0,667		0,47	0,566
0,35	0,649		0,48	0,565
0,36	0,633		0,49	0,564
0,37	0,621		0,50	0,564
NOTE Intermediate values can be obtained by linear interpolation.				

5.4 Ends of other shapes

Ends of shapes other than those covered by 5.3 may be used provided that the adequacy of their design is demonstrated by a fatigue test in accordance with 7.5.2 or by appropriate stress analysis.

5.5 Minimum wall thickness

The minimum wall thickness of each pressure part shall be the greater of that required by:

- for cylindrical shells, 5.2 or that required to meet the tests described in 8.2,
- for ends, 5.3 or 5.4, as appropriate, or that required to meet the tests described in 8.2.

5.6 Design of openings

5.6.1 All openings shall be located in one end of the cylinder.

5.6.2 Each opening in the cylinder shall be reinforced, either by a valve boss or pad securely attached by welding. The suitability of the design of the reinforcement or design changes within an approved type of cylinder shall be confirmed by design calculations or a fatigue test in accordance with 7.5.2.

5.6.3 The welds of the opening reinforcement shall be not less than $\sqrt{2,5bD}$ mm from any circumferential joints.

5.6.4 Unless otherwise specified, valve boss threads shall conform to a recognised specification.

NOTE Suitable thread specifications include EN ISO 11363-1 for 17E and 25E thread.

5.7 Valve protection

The design of a cylinder and its over-moulded casing, where applicable, shall provide protection for the valve/s against damage in order to avoid the release of the cylinder contents, unless the valve/s are protected by other means. Where the casing provides protection, it shall be regarded as part of the complete cylinder.

When the valve protection is integral with the cylinder, this shall be demonstrated by drop testing in accordance with the requirements of 6.7 of EN ISO 11117:2008 or for hot air balloon cylinders the drop testing shall be in accordance with the drop tests specified in 7.5.5.

NOTE The requirement for this test can be considered to have been met if the drop tests specified in 7.5.4 or for hot air balloon cylinder 7.5.5 are carried out with the cylinder valve/s (and fittings) in place and the acceptance criteria as defined in EN ISO 11117 are met.

When the cylinder is not provided with integral valve protection, the manufacturer should specify that cylinders containing LPG should be conveyed in crates or cradles or should be provided during transportation with some other effective valve protection. Otherwise the manufacturer should specify that the cylinder should be fitted with valves that have demonstrated, by impact tests in accordance with EN ISO 14245 or EN ISO 15995, that the valve can withstand damage without leakage of the contents.

5.8 Non-pressure containing attachments welded to the cylinder

5.8.1 Attachments shall be designed so as to avoid trapping water and to permit external inspection of the attachment welds. They shall be clear of longitudinal and circumferential joints.

5.8.2 Where a footring is fitted, it shall be of adequate strength to provide stability and be attached so that it does not prevent inspection of any pressure containing welds. Any footring shall be suitably drained and the space enclosed by the footring suitably ventilated e.g. by means of openings.

5.9 Resistance against external corrosion

Non stainless steel cylinders built according to this standard shall be coated or protected against external corrosion. Stainless steel may be coated or protected against external corrosion. The coating and protection shall comply with the performance test requirement of 7.3.7. Only stainless steel or coated cylinders may additionally be protected by over-moulding – see 5.10.

5.10 Over-moulded cylinders

5.10.1 The over-moulded case shall be polyurethane or a material which provides the same protection. The over-moulding shall be applied to a coated cylinder which meets the requirements of 7.3.7.1. Over- moulded case shall protect the coating and provide protection to the metal cylinder against corrosion as required in 7.3.7 and shall be designed to withstand the drop test requirements of 7.5.4.

5.10.2 The design of over- moulded cases shall facilitate manual handling, stowage and stacking without impeding access to the valve for the purposes of filling, emptying, maintenance and replacement.

5.10.3 The material used for the over-moulding shall be of the dense semi-rigid cellular plastic type, with an integral skin of mostly closed cells.

5.10.4 The design life of the cellular plastic over-moulding shall be not less than the life time of the design type of the over-moulded cylinder.

5.10.5 The over moulding shall be applied in a thermosetting casting process.

5.10.6 The over-moulding shall not cover the cylinder serial number and if the other permanent marks are covered by the over-moulding they shall be moulded into the over-moulding or on a plate entrained within the over-moulding. Where a separate plate is used it shall also be marked with the cylinder serial number.

5.10.7 Additional details on the design of over-moulded cylinders are given in Annex B.

NOTE Figure B.1 displays an example of an over-moulded cylinder.

5.10.8 The material used for the over-moulding shall be of the dense semi-rigid cellular plastic type, with an integral skin of mostly closed cells.

5.10.9 The design life of the cellular plastic over-moulding shall be not less than the life time of the design type of the over-moulded cylinder.

5.10.10 The over moulding shall be applied in a thermosetting casting process.

5.11 Hot air balloon cylinders

The manufacturer should specify that cylinders, for use in hot air balloons, shall be transported, when more than nominally empty, with their protective sleeve fitted and within the balloon basket or with additional protection.

6 Construction and workmanship

6.1 General

Cylinder manufactures shall have a documented quality system to ensure that the requirements of this standard are fulfilled and are correctly applied.

6.2 Environment

The environmental impact of welding and allied processes shall be assessed in accordance with EN 14717.

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

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

6.3 Welding qualification

6.3.1 Welding associated with the pressure envelope including non-pressure-containing parts shall:

- have welding procedure specifications for all joints in accordance with EN ISO 15609-1, qualified in accordance with EN ISO 15614-1 or EN ISO 15613;
- be done by welders approved in accordance with EN ISO 9606-1 and welding personnel in accordance with EN ISO 14732.

6.3.2 Welding procedure approval tests shall be on welds that are representative of those made in production.

6.3.3 Welders shall have passed the approval tests for the specific type of work and procedure to be performed.

6.3.4 The manufacturer shall maintain the records of the above tests.

6.4 Plates and pressed parts

6.4.1 The manufacturer shall ensure that pressure parts of the cylinders are of uniform quality and free from visible defects, which may ultimately affect the cylinder integrity.

6.4.2 In the case of cylinders manufactured from stainless steel, care shall be taken to avoid contamination from other manufacturing materials.

Any hot forming process should be designed to minimise energy consumption and ensure the environmentally friendly disposal of insulating material and other waste.

Material off-cuts should be processed for recycling.

6.5 Welded joints

6.5.1 The welding of the longitudinal and circumferential joints shall be a fully mechanised or automatic process so as to provide consistent and reproducible welds.

6.5.2 There shall be no more than one longitudinal joint, which shall be butt-welded, and this weld shall not be of the joggled type. Permanent backing strips shall not be used with longitudinal welds.

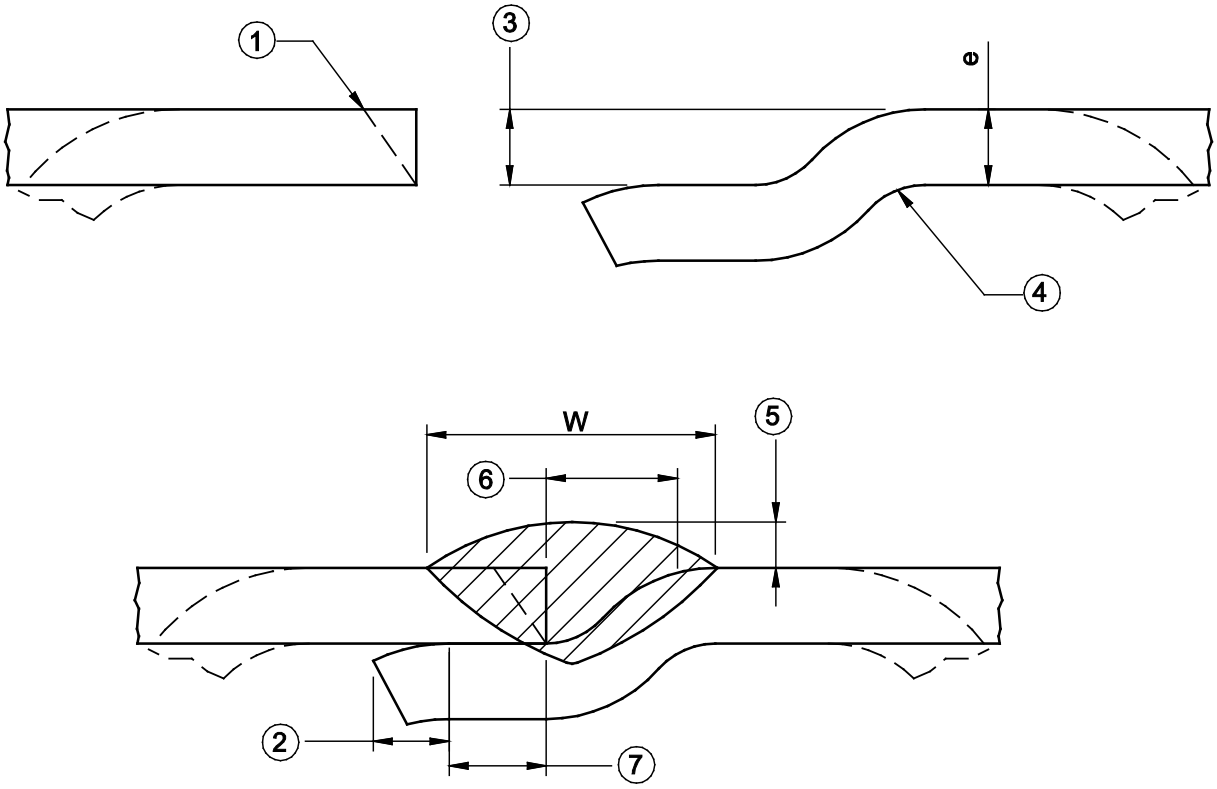
6.5.3 There shall be no more than two circumferential joints which shall be butt welded or butt welded with one member offset to form an integral backing strip i.e. joggled, see Figure 4.

6.5.4 Before the cylinders are closed, longitudinal welds shall be visually examined from both sides in accordance with EN ISO 17637.

6.5.5 The fusion of the welded metal with the parent metal shall be smooth and free from overlapping, undercutting or abrupt irregularity. There shall be no cracks, notching or porous patches in the welded surface and the surface adjacent to the weld. The welded surface shall be regular and even without concavity.

6.5.6 Butt welds and joggled butt welds shall have full penetration. Unless the welding process can demonstrate full penetration throughout the weld, joggled butt-welds may have a lack of penetration at the start of the weld (with a maximum length of 5 mm) if located under the overrun zone and it is demonstrated during production testing that this is not the weakest point of the cylinder. The minimum length of weld-overrun shall be 10 mm.

The excess thickness shall not exceed 25 % of the width of the weld.



Key

1 bevel optional
2 as desired
3 depth of offset to give a close fit on the mating part
4 inside of cylinder – (sharp break to be avoided)
5 height of weld (except in weld-overrun zone) ≤ W/4
6 width of bevel: 2,5e ≥ width of bevel ≥ e
7 minimum contact length: 1,5e
e thickness of metal which is offset
W width of weld: 8e ≥ W ≥ 3e

Figure 4 — Illustration of a typical circumferential joggled weld butt joint

6.6 Tolerances

6.6.1 Out-of-roundness

The out-of-roundness of the cylindrical shell shall be limited so that the difference between the maximum and the minimum outside diameter in the same cross-section is not more than 1 % of the mean of these diameters for two piece cylinders and 1,5 % for three piece cylinders.

6.6.2 Straightness

The maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 0,3 % of the cylindrical length.

6.6.3 Verticality

When the cylinder is standing on its base, the cylindrical shell and the axis of the top opening shall be vertical to within an angle of 1,5°.

6.7 Closure of openings

To protect the thread from damage and to prevent entry of moisture into the cylinder, openings in finished cylinders shall be either:

- fitted with a plug of suitable non-absorbent material, or
- fitted with the appropriate valve or fitting.

6.8 Heat treatment

6.8.1 Cylinders manufactured using steel in accordance with EN 10120 shall be heat treated (normalised or stress relieved), unless the requirements of 6.8.3 have been satisfied.

When using other steels, the manufacturer shall specify and carry out any heat treatment necessary to achieve the material properties required by the design.

6.8.2 The cylinder manufacturer shall maintain records of heat treatment carried out.

6.8.3 Cylinders manufactured using steel in accordance with EN 10120, need not be heat treated provided all the following requirements are met:

- cylinders are of three-piece construction,
- ends are semi ellipsoidal or torispherical in accordance with Figure 1 and the depth of pressing is limited such that:

$$\frac{H - b}{D} \leq 0,26$$

and

$$h \leq 8b$$

- cylinders are made from a fine grain steel with maximum grain size of 8, in the delivery condition, when tested in accordance with EN ISO 643 and
- three samples of each type, are subject to a fatigue test in accordance with 7.5.2. Any subsequent change in design, material thickness, material specification or weld procedure shall require a further set of fatigue tests.

6.8.4 Hot air balloon cylinders that are subject to ambient temperature cold forming after fabrication shall not be subjected to any subsequent heat treatment or to additional heat application, such as welding.

The heat treatment process should be designed to minimise energy consumption and ensure the environmentally friendly disposal of insulating material and other waste.

7 Tests and examinations

7.1 General

Clause 7 sets out the test and examinations that shall be undertaken for both ‘type approval’ and production testing. All tests and examinations shall be documented; production tests shall be referenced to the ‘type approval’ documents.

Cylinders in accordance with this European Standard are subject to the conformity assessment system outlined in Clause 8 and Clause 9 consisting of the testing and approval of the design type, the recognition of

quality assurance for the production and the initial inspection and testing of cylinders manufactured according to the design type.

7.2 Types of test and evaluation of test results

The tests and examinations to be applied to cylinders shall be in accordance with Clause 8 and Clause 9. The applicability of tests is shown in Table 2.

Table 2 — Applicability of tests/examinations

Test/examination		Clause	Type tests		Production tests			
					Production batch tests		All cylinders	
				Specified in sub-clause		Specified in sub-clause		Specified in sub-clause
Mechanical	Tensile	7.3.5	X	8.2.3	X	9.8.3.2, 9.8.3.3	-	-
	Bend	7.3.6	X	8.2.3	X	9.8.3.2, 9.8.3.3	-	-
Corrosion		7.3.7	X	8.2.7, 7.3.7.3	Z	9.10	-	-
Over-moulding material properties		7.3.7.3.4	X	7.3.7.3.4	-	-	-	-
Radiographic		7.4.1	O	8.2.3	X	9.2, 9.4	X	9.2, 9.4
					O	9.8.3.2, 9.8.3.3	-	-
					Y	9.9	Y	9.6
Macro		7.4.2	O	8.2.3	X	9.3, 9.4, 9.5, 9.3.1, 9.3.2	X	9.3, 9.5
					O	9.8.3.2, 9.8.3.3	-	-
					Y	9.8	Y	9.6
Visual		7.4.3	X	8.2.5	-	-	X	9.1.1, 9.1.2
Burst		7.5.1	X	8.2.4	X	9.8.3.2, 9.8.3.3	-	-
Fatigue		7.5.2	X	8.2.2	-	-	-	-
Impact		7.5.3	X	8.2.8	-	-	-	-
Drop (except Hot Air Balloon cylinders)		7.5.4	X	8.2.9	-	-	-	-
Drop (Hot Air Balloon cylinders only)		7.5.5	X	8.2.9	-	-	-	-
Pressure		9.1.2	-	-	-	-	X	9.7
Vacuum		8.2.6	X	8.2.6	-	-	-	-
Neck Threads		9.1.2	X	9.1.2	-	-	X	9.1.2
Markings		9.1.2	X	9.1.2	-	-	X	9.1.2
Verification of conformance with Type Approval		9.8.4	-	-	X	9.8.4	-	-

Water absorption (over-moulded cylinders only)	7.3.7.3.4.	X	7.3.7.3.4	Z	9.11	-	-
Documentation	11	X	-	X	-	X	11, 12
O This allows for an option of a radiograph or macro X No option permitted – test shall be performed Y Retest required under certain circumstances Z Carried out by the organisation which applies the non-removable protection (over-moulded cylinders only)							

7.3 Test specimens and related tests and examinations

7.3.1 All cylinders

The mechanical tests and the macro examination for checking the properties of the parent metal and welds of the pressure containing parts of the cylinders shall be carried out on test specimens taken from finished cylinders. The dimensions and positions of test specimens are detailed in the following section.

7.3.2 Two-piece cylinders

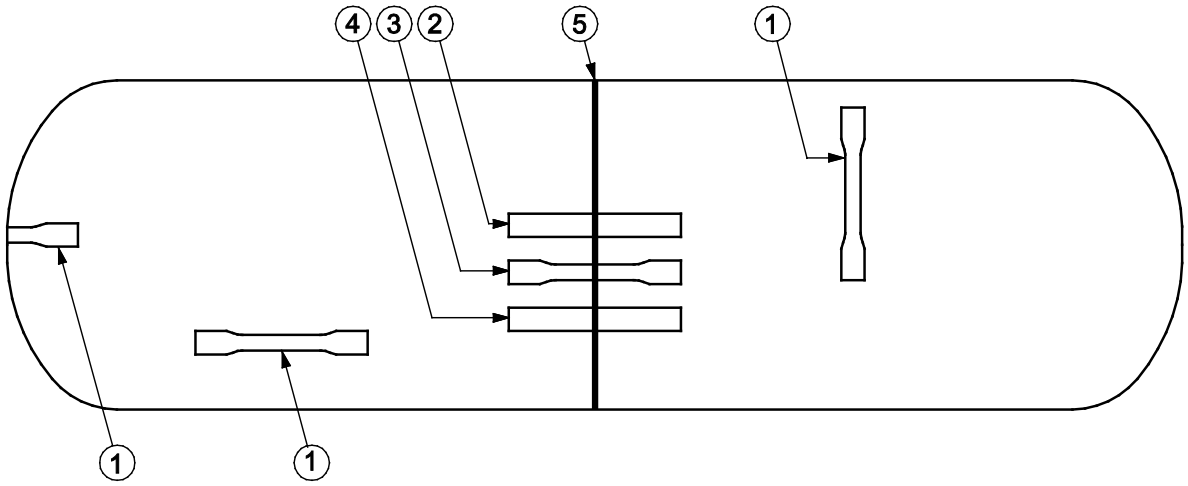
For cylinders containing only circumferential welds (two-piece cylinders), test specimen (as detailed in Table 3 — Types of tests and details (two-piece cylinders)) shall be taken from the places shown in Figure 5.

Test pieces that are not sufficiently flat, shall be flattened by cold pressing.

In all bend test specimens, the weld shall be machined flush with the parent metal surface including any joggled material (see Figure 8 b).

Table 3 — Types of tests and details (two-piece cylinders)

Type	In accordance with	Key (see Figure 5)	Details
1 tensile test	EN ISO 6892-1	1	Parent metal in the geometric longitudinal direction of the cylinder or, if it is not possible, in the circumferential direction, or the centre of one dished end.
1 bend test	EN ISO 5173	2	On the topside of the circumferential weld.
1 tensile test	EN ISO 4136	3	Perpendicular to the circumferential weld.
1 bend test	EN ISO 5173	4	On the underside of the circumferential weld.
1 macro examination	EN ISO 17639		On a randomly selected location on the circumferential weld.



Key

1 alternative locations of test specimen for tensile test
2 test specimen for bend test (topside of the weld)
3 test specimen for cross-weld tensile test
4 test specimen for bend test (underside of the weld)
5 circumferential weld

Figure 5 — Test specimens taken from two-piece cylinders

7.3.3 Three-piece cylinders

7.3.3.1 For cylinders with longitudinal and circumferential welds (three-piece cylinders), test specimens (as detailed in Table 4 — Types of tests and details (three-piece cylinders)) shall be taken from the places shown in Figure 6.

7.3.3.2 Test pieces that are not sufficiently flat, shall be flattened by cold pressing.

In all bend test specimens, the weld shall be machined flush with the parent metal surface including any joggled material, see Figure 8 b).

Table 4 — Types of tests and details (three-piece cylinders)

Type	In accordance with	Key (See Figure 6)	Details
1 tensile test	EN ISO 6892-1	1	Parent metal of cylindrical part in the longitudinal direction or, if this is not possible, in a circumferential direction.
1 tensile test	EN ISO 6892-1	2	Parent metal from one dished end.
1 bend test	EN ISO 5173	3	On the topside of longitudinal weld.
1 bend test	EN ISO 5173	4	On the topside of a circumferential weld.
1 tensile test	EN ISO 4136	5	Perpendicular to the longitudinal weld.
1 bend test	EN ISO 5173	6	On the underside of the longitudinal weld.
1 tensile test	EN ISO 4136	7	Perpendicular to a circumferential weld.
1 bend test	EN ISO 5173	8	On the underside of a circumferential weld.
1 macro examination	EN ISO 17639		On a randomly selected location on a circumferential weld.

7.3.4 Bung welds

The welding of the bung shall be checked by radiographic or macro examination in accordance with 9.2 or 9.3

7.3.5 Tensile test

7.3.5.1 Parent metal

7.3.5.1.1 Procedure

The preparation of test specimens and procedure for carrying out the tensile test shall be in accordance with EN ISO 6892-1.

The two faces of the test specimen representing the inside and outside walls of the cylinder respectively shall not be machined.

7.3.5.1.2 Requirements

The values obtained for yield strength, tensile strength and elongation shall be not less than those guaranteed by the cylinder manufacturer in the finished cylinder.

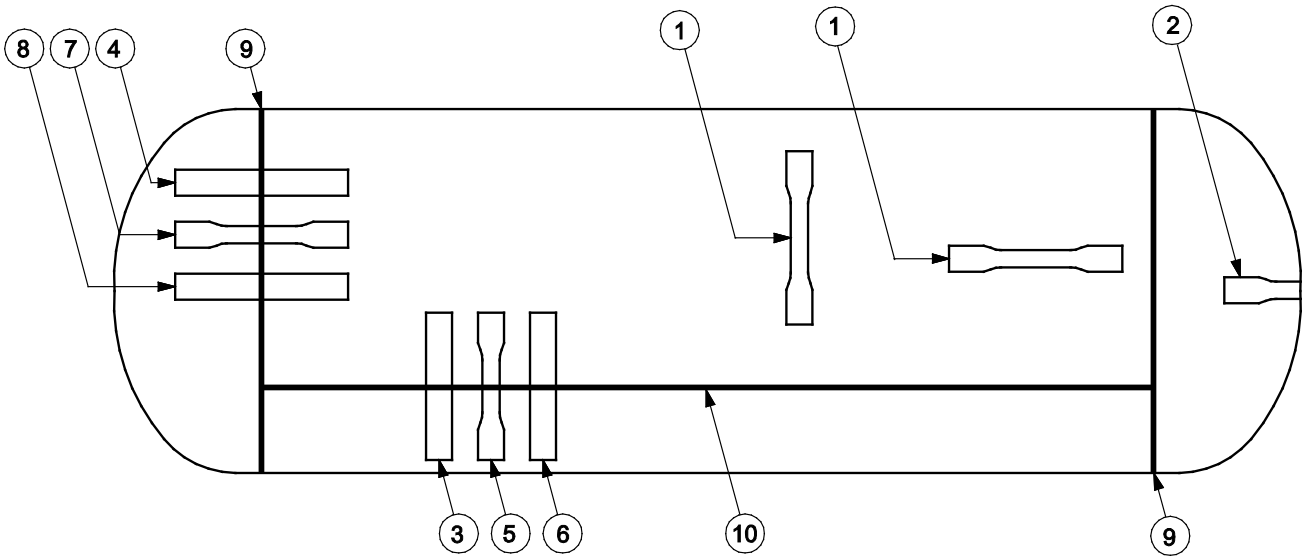
7.3.5.2 Welds

7.3.5.2.1 Procedure

The tensile test perpendicular to the weld shall be carried out in accordance with EN ISO 4136 on a test specimen having a reduced cross section of 25 mm in width for a length extending up to 15 mm beyond the edges of the weld (see Figure 7). Beyond this central part, the width of the test specimen shall increase progressively.

7.3.5.2.2 Requirements

The tensile strength value obtained during the test, R_m, shall not be less than that guaranteed by the cylinder manufacturer R_g in the finished cylinders.



Key

1 alternative locations of test specimens for tensile test
2 test specimen for tensile test
3 test specimen for bend test (topside of the weld)
4 test specimen for bend test (topside of the weld)
5 test specimen for tensile test
6 test specimen for bend test (underside of the weld)
7 test specimen for tensile test
8 test specimen for bend test (underside of the weld)
9 circumferential weld
10 longitudinal weld

Figure 6 — Test specimens taken from three-piece cylinders

Dimensions in millimetres

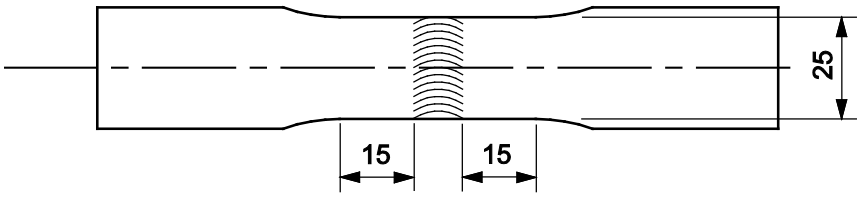


Figure 7 — Test specimen for tensile test perpendicular to the weld

7.3.6 Bend test

7.3.6.1 Procedure

7.3.6.1.1 The preparation of test specimens and procedure for carrying out a bend test shall be in accordance with EN ISO 5173.

7.3.6.1.2 The bend test specimens shall be 25 mm in width. A mandrel shall be placed in the centre of the weld while the test is being performed (see Figure 8).

7.3.6.1.3 The specimen shall be bent round the mandrel through an angle of 180° (see Figure 8 (c)).

7.3.6.1.4 The ratio *n* between the diameter of the mandrel D_p and the thickness of the test specimen (*e*) (see Figure 8 (c)) shall not exceed the values given in Table 5.

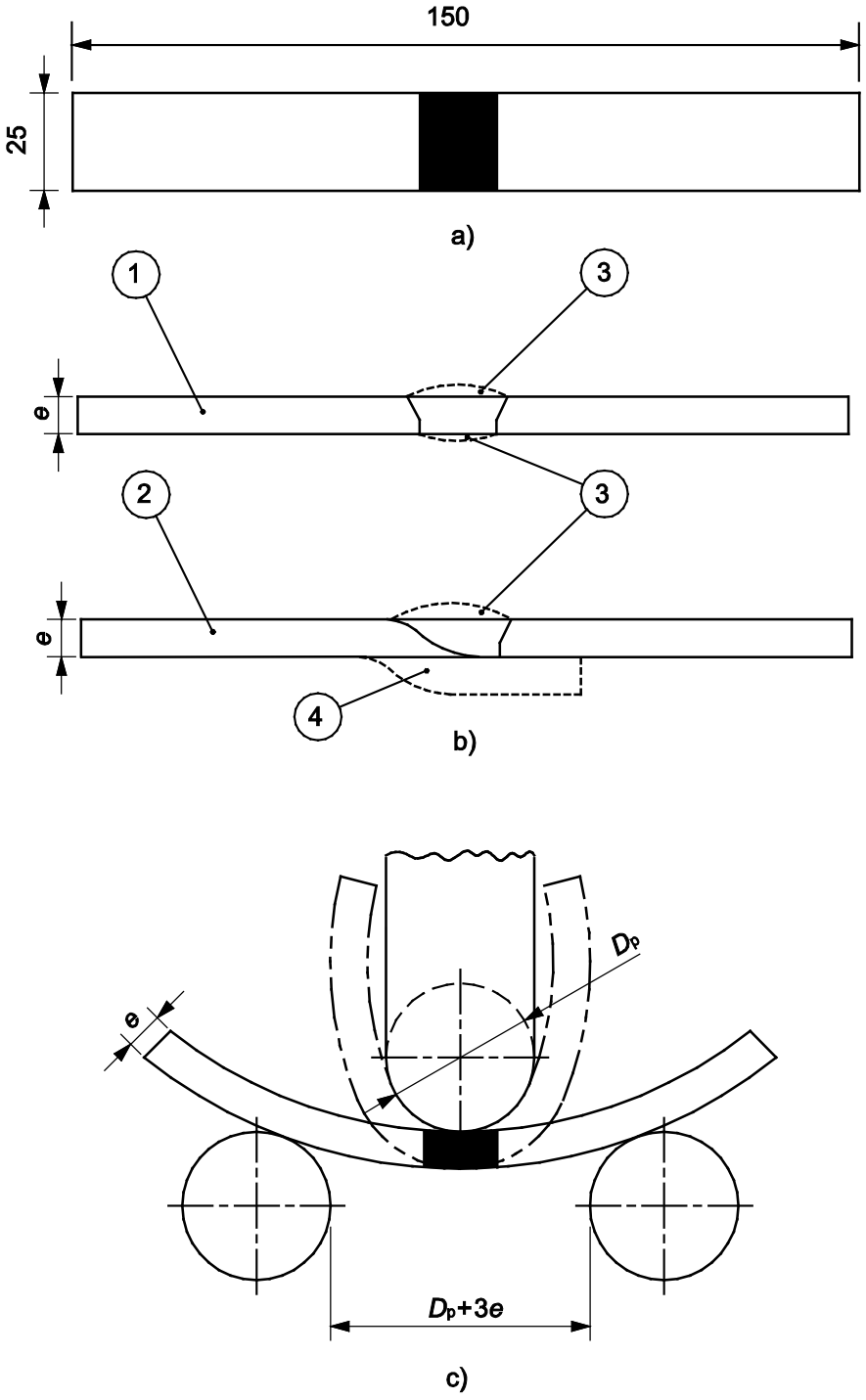
7.3.6.2 Requirements

No cracks shall be visible in the test specimen after bending.

Table 5 — Ratio of mandrel diameter and test piece thickness

Actual measured tensile strength R_m N/mm^2	**Value of *n***
Up to 440 inclusive	2
Above 440 to 520 inclusive	3
Above 520 to 600 inclusive	4
Above 600 to 700 inclusive	5
Above 700 to 800 inclusive	6
Above 800 to 900 inclusive	7
Above 900	8

Dimensions in millimetres



Key

a) dimensions of test specimen
b) transverse guided bend test specimen preparation
c) illustration of bend test
1 butt weld specimen
2 joggle weld specimen
3 weld dressed flush
4 joggled portion to be removed

Figure 8 — Bend tests

7.3.7 Resistance to external corrosion

7.3.7.1 Coated cylinders

7.3.7.1.1 Procedure

7.3.7.1.1.1 The test requirements and the relevant standards are detailed in Table 6.

7.3.7.1.1.2 The tests specified in Table 6 shall be carried out on standard test plates in accordance with the specified standards except the adhesion tests, which shall be carried out on test pieces taken from one finished cylinder.

7.3.7.1.1.3 On completion of the climatic test, the salt spray test and the water immersion test, the test plates used shall then be subject to a cross-cut and a pull-off adhesion test.

7.3.7.1.2 Requirements

The requirements are detailed in the column “Acceptance values” in Table 6.

Table 6 — External corrosion tests for coated cylinders

Test type	Test details	Standard	Acceptance values
Adhesion	Cross-cut test, with adhesive tape	EN ISO 2409:2013	Before climatic/salt spray/water test:- Table 1 – Classification ≤1 After climatic/salt spray/water test:- Table 1 – Classification ≤ 3
	Pull-off test	EN ISO 4624	Values listed in 7
Climatic test	Resistance to cyclic corrosion conditions – wet (salt fog)/dry/humidity/UV light, using scribed panels	EN ISO 11997-2	Surface blistering density = 0 degree of rusting = Ri0 cracking to substrate, type (c) = 0 flaking to substrate, type (b) = 0 Adjacent to scratch extent of rusting ≤ 3mm blistering = size 4
	Resistance to humid atmospheres containing SO_2, including environmental cabinet exposure. 0,2 l SO_2, 28 cycles	EN ISO 3231:1997, utilising 9.3 b)	blistering = 0 degree of rusting = 0
Salt spray	720 h exposure on scratched surfaces. (2 scratches)	EN ISO 9227	Surface blistering density = 0 degree of rusting = Ri0 cracking to substrate, type (c) = 0 flaking to substrate, type (b) = 0 Adjacent to scratch : extent of rusting ≤ 3mm blistering = size 4
Water resistance	400 h exposure	EN ISO 2812-2	blistering = 0 no other signs of deterioration

Table 7 — Pull-off test values for Table 6

Conditions test	Painting with hot zinc spraying	Painting applied directly on substrate
New paint – Type A break (until metal substrate)	2 MPa	8 MPa
New paint – Type B break (cohesive break in paint layer)	Not required	6 MPa
After aging test – Type A break (until metal substrate)	1 MPa	4 MPa
After aging test – Type B break (cohesive break in paint layer)	Not required	3 MPa

7.3.7.2 Non-coated cylinders

7.3.7.2.1 Procedure

Test specimens shall be cut from a finished cylinder to include circumferential and longitudinal welds and areas of maximum deformation of the material. These specimens shall be subject to a salt spray test for a period of 720 h.

7.3.7.2.2 Requirements

On completion of the tests there shall be no evidence of corrosion on the exposed surfaces.

NOTE These tests are not required for stainless steel hot air balloon cylinders.

7.3.7.3 Over-moulded cylinders

7.3.7.3.1 Over-moulded protective case design

The over-moulding shall be tested for adhesion.

7.3.7.3.2 Adhesion test procedure

7.3.7.3.2.1 General

This additional test shall be carried out on one finished over-moulded cylinder.

7.3.7.3.2.2 Preparation

The epoxy adhesive components used in this test procedure shall be stored according to the manufacturer instructions.

The adhesion test block shall be aluminium with a diameter of 20 mm and of suitable length for testing.

The over-moulded cylinder to be tested shall be stored at (23 ± 2) °C for a minimum of 24 h before preparation and curing of the adhesive.

The test shall be carried out at (23 ± 2) °C and at a relative humidity of (50 ± 5) %.

The ambient conditions shall be recorded on the test report.

The test area shall be prepared by lightly sanding with an abrasive material.

Any paint on the over-moulded case shall be removed with an abrasive material.

The adhesion test block shall be glued to the over-moulded case using an epoxy type adhesive. The epoxy adhesive shall be allowed to cure for a minimum period of 48 h after application and as required by the manufacturer's instructions.

The over-moulded case around the adhesion test block shall be cut through to the steel surface of the cylinder.

7.3.7.3.2.3 Breaking strength

The adhesion test block shall be placed in the pull-off adhesion tester, taking care to align the adhesion test block so that the tensile force is applied uniformly across the over-moulded cylinder wall.

A tensile stress, increasing at a rate not greater than 1 MPa/s, perpendicular to the plane of the substrate shall be applied.

7.3.7.3.2.4 Results

The acceptance values shall be in accordance with Table 8 (type test) and Table 10 (production test).

The following data shall be recorded:

a) the breaking strength measured by the pull-off adhesion tester; and

b) the type of fracture and the percentage of pulled-off area.

7.3.7.3.2.5 Test report

The test report shall contain at least the following information:

a) all details necessary to identify the product(s) tested;

b) the results of the test as per 7.3.7.3.2.4;

c) the type of the cutting tool employed to cut around the adhesion test block; and

d) the date of the test.

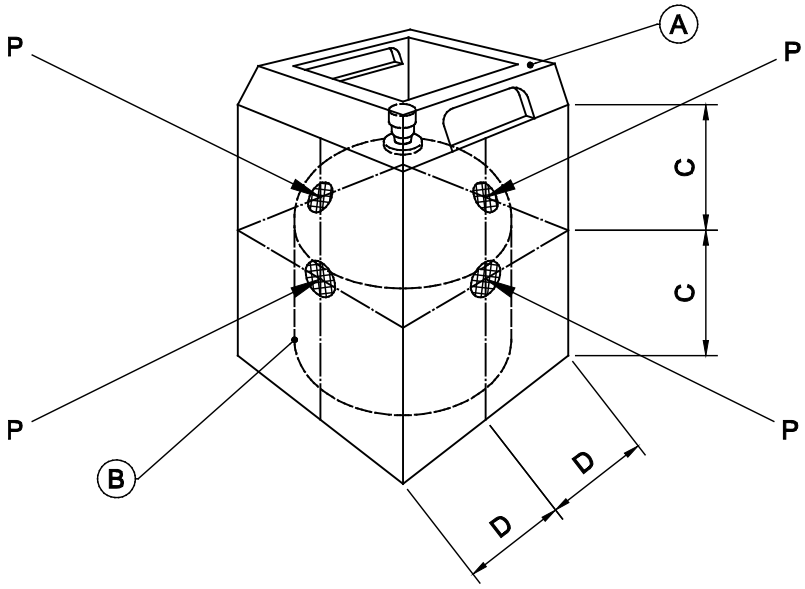
7.3.7.3.3 Requirements

The type test requirements and acceptance values are detailed in Table 8.

The production test requirements and acceptance values are detailed in Table 10.

Table 8 — Resistance to external corrosion type test for over-moulded cylinders

Test type	Test details	Acceptance value
Adhesion of protecting material on coating test	5 pull-off tests at mid height (on the sides) every 90° and on the bottom as illustrated in Figure 9. See procedure in 7.3.7.3.2.	Breaking strength > 2,5 MPa per test. Breaking shall occur into the protecting material layer or between the protecting material and the adhesive.



Key

A over-moulded case

B steel cylinder

C equidistant dimension (4 places)

D equidistant dimension (4 places)

P location of adhesion test block for pull off test

Figure 9 — Pull-off test locations

7.3.7.3.4 Over-moulding material requirements

The over-moulding material shall meet the following requirements:

7.3.7.3.4.1 The applied cellular plastic shall be resistant to water absorption. The cellular plastic shall not absorb more than 0,05 grams of water per gram (5 % by mass) of cellular plastic coating material when the finished cylinder is totally immersed in a water bath for a period of 72 h (water temperature of 25 °C). This test shall be undertaken on the over-moulded cylinder before any paint is applied after the moulding operation.

7.3.7.3.4.2 In addition to the drop test requirements of 7.5.4.1, the cellular plastic material shall be subjected to a load resistance test. A sample 16 mm in diameter and 10 mm high shall be subjected to an equally distributed load of 70 N, placed on one of the flat faces of the sample. The sample shall be subjected to this load for a period of 72 h at a temperature of 50 °C. Following the completion of the test the load shall be removed and the sample shall return to within 1 mm of the original height within 5 min of the load being removed.

7.3.7.3.4.3 If the over-moulding is to be painted, the properties of the cellular plastic shall not be degraded by the paint.

7.4 NDT

7.4.1 Radiographic examination

7.4.1.1 Procedure

Radiography of welds shall be carried out in accordance with EN ISO 17636-1:2013 or EN ISO 17636-2:2013, class B. Radiography personnel shall be qualified to EN ISO 9712:2012 level 1, and shall be supervised by personnel qualified to EN ISO 9712:2012 level 2.

The extent of radiography shall be as shown in Figure 9 or Figure 10 as appropriate.

Dimensions in millimetres

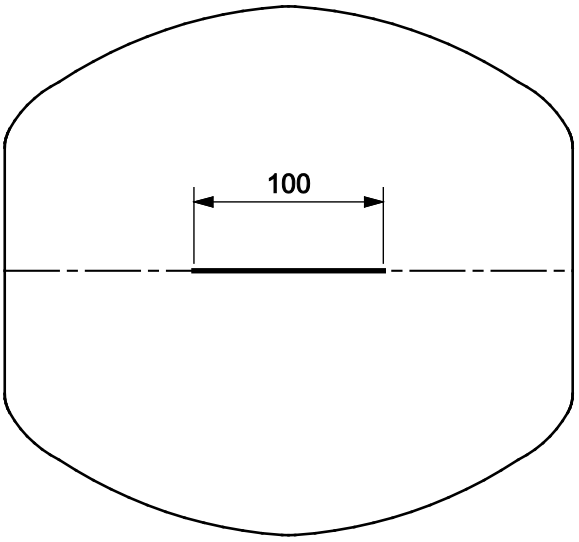


Figure 10 — Extent of radiography of welds – Cylinders with circumferential welds only

Dimensions in millimetres

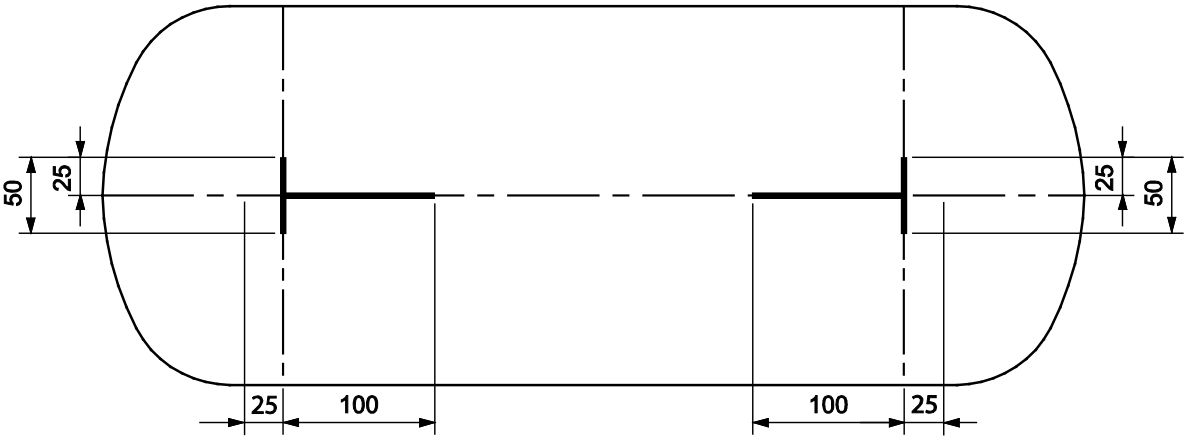


Figure 11 — Extent of radiography of welds – Cylinders with circumferential and longitudinal welds

7.4.1.2 Assessment

Assessment of the radiographic films shall be based on the original films in accordance with EN ISO 19232-1 and EN ISO 19232-2.

7.4.1.3 Requirements

The following imperfections as defined in EN ISO 6520-1 are not permitted:

- cracks;
- lack of penetration;
- lack of fusion of the weld;

- incompletely filled groove;
- root concavity;
- overlap;
- any elongated inclusion or any group of rounded inclusions in a row where the length represented over a weld length of 12 × *e* is greater than 6 mm;
- any gas pore measuring more than *e*/3 mm;
- any gas pore measuring more than *e*/4 mm, which is 25 mm or less from any other gas pore;
- gas pores over any 100 mm length, where the total area, in mm^2, of all the pores is greater than 2*e*.

7.4.2 Macro examination

7.4.2.1 Procedure

The macro examination shall be carried out in accordance with EN ISO 17639.

7.4.2.2 Requirement

Full transverse sections of the welds shall show complete fusion and complete penetration as specified in 7.4.1.3.

If there is a doubt, a microscopic examination shall be made of the suspect area.

7.4.3 Visual examination of the surface of the weld

7.4.3.1 Procedure

The weld shall be examined in accordance with EN ISO 17637 after the weld has been completed. The welded surface examined shall be well illuminated, and shall be free from grease, dust, scale, residue or protective coating of any kind.

7.4.3.2 Requirements

The welds shall comply with 6.5.4 and.6.5.5.

7.5 Prototype and production batch testing

7.5.1 Burst test under pressure

7.5.1.1 Procedure

7.5.1.1.1 If it is intended to apply markings (see Clause 10) on a section of the cylinder subjected to pressure, then the cylinders to be tested shall be similarly marked before testing.

7.5.1.1.2 The burst test under pressure shall be carried out with equipment that:

- enables the pressure to be monitored and increased gradually until the cylinder bursts,
- records the volume of the test liquid used, and
- records the pressure at which the cylinder bursts.

7.5.1.1.3 The cylinder shall be pressurised until it bursts and the volumetric expansion of the cylinder shall be measured as:

- the volume of test liquid used between the time when the pressure starts to rise and at the time of bursting, or

- the difference between the volume of the cylinder at the beginning and the end of the test (see 7.5.1.2.2).

7.5.1.1.4 After the cylinder has burst the rupture surface shall be subject to examination of the tear and the shape of its edges (see 7.5.1.2.3).

7.5.1.2 Requirements

7.5.1.2.1 Bursting pressure

The measured bursting pressure P_b shall not be less than 2,25 times the calculation pressure P_c and at least 50 bar.

7.5.1.2.2 Volumetric expansion of cylinders not intended to be fitted with a pressure relief device

7.5.1.2.2.1 The ratio of the volumetric expansion of the cylinder to its initial volume shall be greater than or equal to:

- 20 % if the length of the cylinder (length of the pressure envelope including the bung) is greater than the diameter *D*, or

- 17 % if the length of the cylinder (length of the pressure envelope including the bung) is equal to or less than the diameter *D*.

7.5.1.2.2.2 Cylinders that do not meet the requirements of 7.5.1.2.2.1 shall have the guaranteed minimum value for volumetric expansion included in the markings and the manufacturer shall specify that the cylinders shall be fitted with a pressure relief device.

7.5.1.2.3 Type of fracture

The burst test shall not cause any fragmentation of the cylinder.

The main fracture shall not show any brittleness, i.e. the edges of the fracture shall not be radial but shall be at an angle to a diametrical plane and display a reduction of area throughout their thickness.

The fracture shall not reveal a visible defect in the metal, e.g. laminations.

The liquid used for the pressure test should be recycled for further use or disposed of with due regard to the environment.

7.5.2 Fatigue test

7.5.2.1 Procedure

7.5.2.1.1 The cylinders shall be filled with a non-corrosive liquid and subjected to successive applications of hydraulic pressure.

7.5.2.1.2 The test shall be carried out at an upper cyclic pressure either:

- equal to two thirds of the test pressure, in which case the cylinder shall be subjected to 80 000 cycles, or

- equal to the test pressure, in which case the cylinder shall be subjected to 12 000 cycles.

7.5.2.1.3 The value of the lower cyclic pressure shall not exceed 10 % of the upper cyclic pressure.

7.5.2.1.4 The frequency of pressure cycling shall not exceed 0,25 Hz (15 cycles/min). The temperature measured on the outside surface of the cylinder shall not exceed 50 °C during the test.

7.5.2.2 Requirements

There shall be no leakage from the cylinder.

7.5.3 Cylinder body integrity impact tests (not required for hot air balloon cylinders)

7.5.3.1 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.

Each type of test shall be carried out on cylinders without any over-moulded casing and without internal pressure.

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 higher than that of the cylinder and sufficiently robust to prevent the impact energy being absorbed by deflection of the striker.

7.5.3.2 Flat surface impact test

7.5.3.2.1 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:

$$F = 30M$$

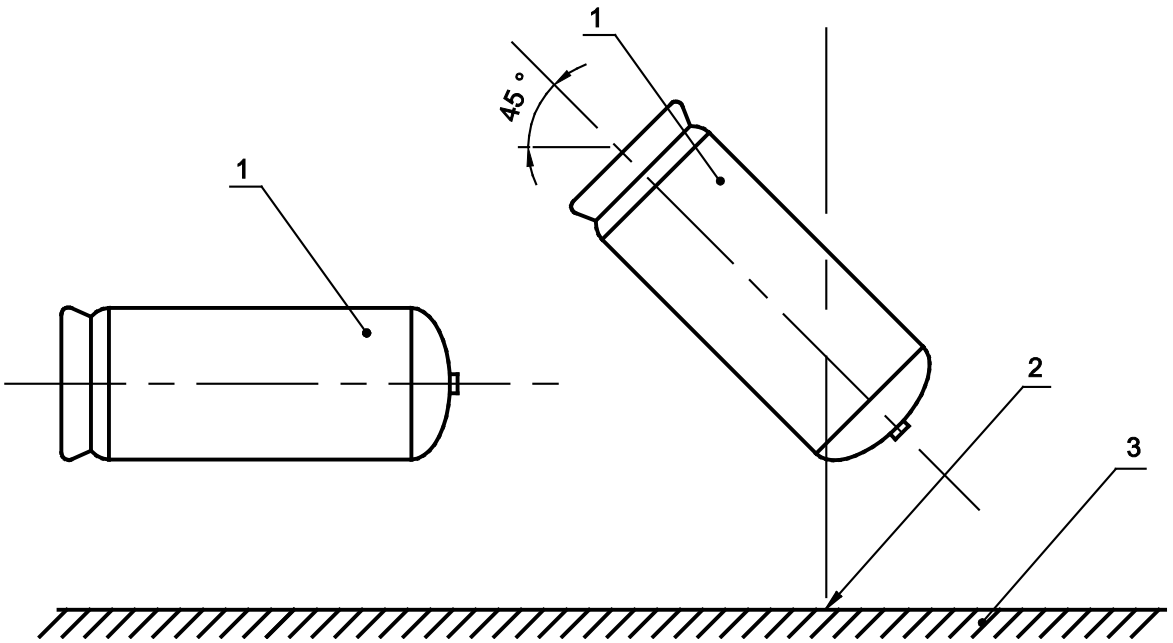
where

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 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 an angle of 45° to the cylinder axis (see Figure 12).



Key

1 cylinder

2 point of impact

3 flat surface

Figure 12 — Impact test with a flat surface

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

If both cylinders show damage equal to or worse than these rejection criteria, then on completion of both impacts, both cylinders shall be subject to a burst test in accordance with 7.5.1.

If the cylinders withstand any of the impacts with visible damage below the rejection criteria in EN 1439, then on completion of both impacts, one cylinder shall be subject to a burst test in accordance with 7.5.1 and the other subject to a fatigue test in accordance with 7.5.2.

7.5.3.2.2 Requirement

After impacts, the pressurised cylinders shall not leak.

Cylinders subject to the burst test shall meet the requirements of 7.5.1.

Cylinders subject to the fatigue test shall meet the requirements of 7.5.2.

7.5.3.3 Edge impact test

7.5.3.3.1 Procedure

The profile of the striker shall be as shown in Figure 13 and the length shall be as shown in Figure 14.

Dimensions in millimetres

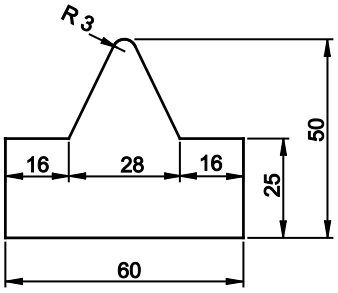


Figure 13 — Striker profile

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.

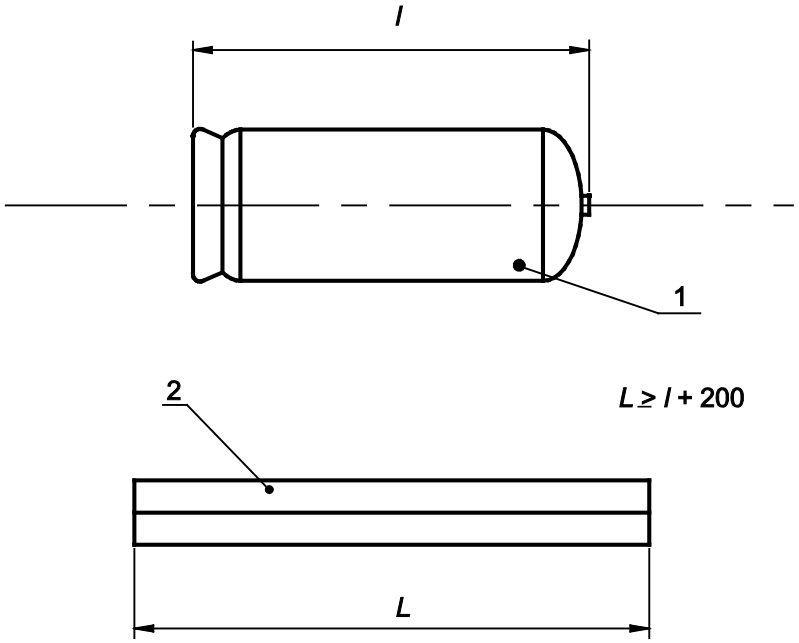
Two cylinders shall each be impacted with the edge parallel to the cylinder axis (see Figure 14). The cylinders shall then be impacted with the edge perpendicular to the cylinder axis (see Figure 15). The position of the two impacts shall be separated by a minimum angle of 45° round the cylinder circumference.

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

If both cylinders show damage equal to or worse than these rejection criteria, then on completion of both impacts, both cylinders shall be subject to a burst test in accordance with 7.5.1.

If the cylinders withstand any of the impacts with visible damage below the rejection criteria in EN 1439, then on completion of both impacts, one cylinder shall be subject to a burst test in accordance with 7.5.1 and the other subject to a fatigue test in accordance with 7.5.1.

Dimensions in millimetres

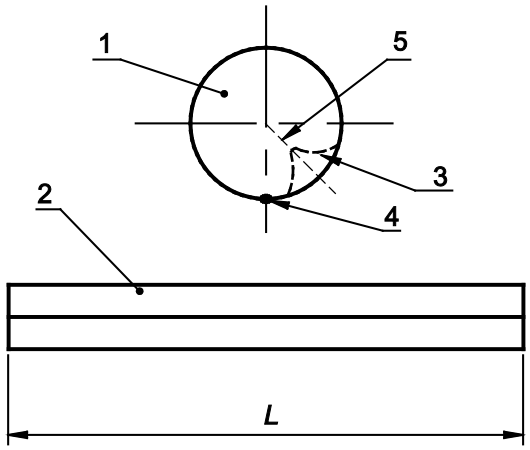


Key

1 test cylinder

2 drop test edge (see Figure 12)

Figure 14 — Impact test with cylinder axis parallel to edge, *L*



Key

1 cylinder

2 drop test edge (see Figure 12)

3 indentation from first drop

4 weld in 3 piece cylinder

5 impact points to be separated by an angle of at least 45°

Figure 15 — Impact test with cylinder axis perpendicular to edge, *L*

7.5.3.3.2 Requirement

After impacts, the pressurised cylinders shall not leak.

Cylinders subject to the burst test shall meet the requirements of 7.5.1.

Cylinders subject to the fatigue test shall meet the requirements of 7.5.2.

7.5.4 Drop tests (all cylinders except hot air balloon cylinders)

7.5.4.1 Procedure

Two cylinders, including any over-moulded casing, foot-ring and/or valve protection shall be weighted to represent the maximum operating mass.

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 16 i.e. 10 drops per cylinder.

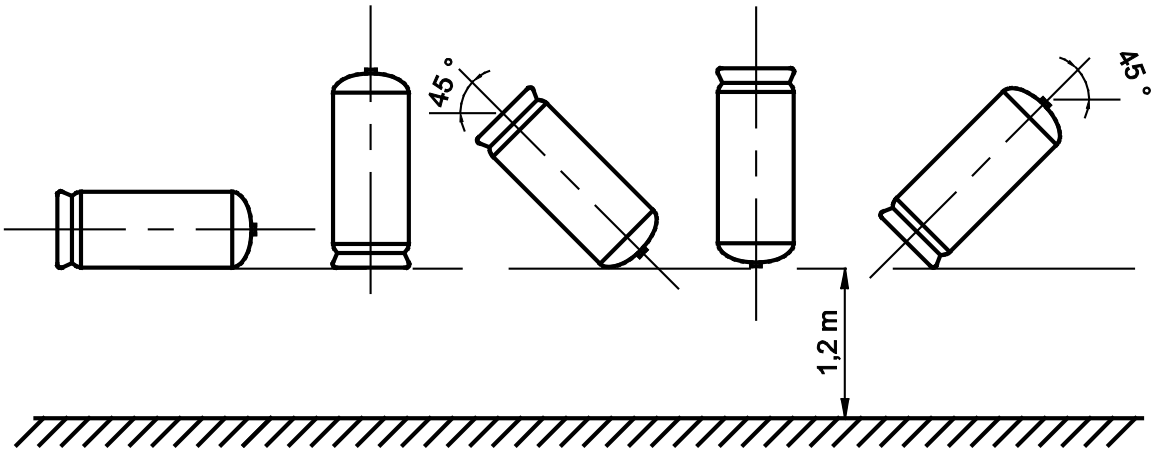


Figure 16 — Orientations for 1,2 m drop onto flat surface

The surface shall consist of a steel plate a minimum of 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.

After each drop, the cylinders shall be visually examined for signs of damage and assessed against the rejection criteria in EN 1439.

If both cylinders show damage equal to or worse than the rejection criteria, then on completion of all ten drops, both cylinders shall be subject to a burst test in accordance with 7.5.1.

If the cylinders withstand any of the drops with visible damage below the rejection criteria in EN 1439, then on completion of all ten drops, one cylinder shall be subject to a burst test in accordance with 7.5.1 and the other subject to a fatigue test in accordance with 7.5.2.

7.5.4.2 Requirement

After ten drops, the cylinders shall not leak.

Cylinders subject to the burst test shall meet the requirements of 7.5.1.

Cylinders subject to the fatigue test shall meet the requirements of 7.5.2.

Following the tests; all parts and cylinders that are not being retained (for record purposes) should be processed for recycling.

7.5.5 Drop tests (hot air balloon cylinders only)

7.5.5.1 Procedure

7.5.5.1.1 Drop tests shall be carried out on a minimum of two representative cylinders. The samples for drop testing shall be representative of the operational configuration (i.e. valves, fittings, protective cover).

7.5.5.1.2 The impact surface shall be as defined in 7.5.4.1.

7.5.5.1.3 The cylinders shall be filled with water to represent the typical maximum operating mass. The cylinders shall not be pressurised for the drop test.

7.5.5.1.4 The drop test procedure shall be as follows:

a) one cylinder shall be dropped from a height of 1,2 m with the bottom of the cylinder striking the impact surface as illustrated in Figure 17 a);

b) one cylinder shall be dropped from a height of 1,2 m with the cylinder side wall striking the impact surface as illustrated in Figure 17 b);

c) one cylinder shall be dropped from a height of 1,2 m with the cylinder guard or other valve protection striking the impact surface at an angle of 30^0 as illustrated in Figure 17 c). The cylinder shall be rotated, about its long axis, so that the weakest point of the shroud strikes the impact surface:

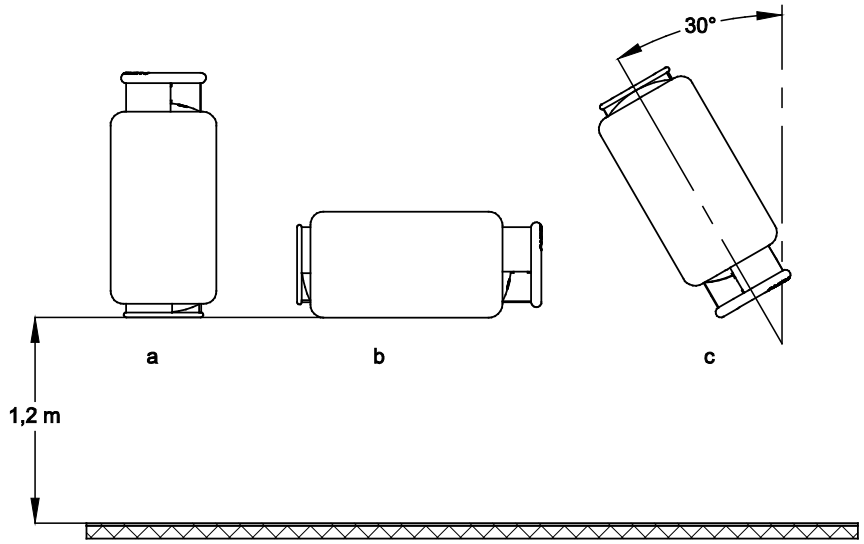


Figure 17 — Hot air balloon cylinder drop test

7.5.5.2 Requirements

The acceptance criteria for the drop test shall be as follows.

The cylinder shall exhibit no leakage, the liquid withdrawal valve shall remain operational and the cylinder shall pass a burst test as described in 7.5.1.

Following the tests; all parts and cylinders that are not being retained (for record purposes) should be processed for recycling.

8 Technical requirements for type approval

8.1 General

The compliance of any new type of cylinder with this standard shall be demonstrated by the tests outlined in this clause. Types of cylinders shall be specified in technical drawings, parts lists and materials specifications.

For cylinders with over-moulding or a protective casing, the design and materials of the over-moulding or casing shall be recorded on the type approval certificate.

The cylinders used for the tests shall be representative of this specification.

The results of the type tests shall be documented and summarised in a test report as a basis for the type approval of the design.

8.2 Extent of testing

8.2.1 For all types, except hot air balloon cylinders, the manufacturer shall make available a production batch of at least 50 cylinders of each type, which shall be guaranteed as being representative of the production cylinders. For hot air balloon cylinders the manufacturer shall make available a production batch of at least 16 cylinders of each type, which shall be guaranteed as being representative of the production cylinders

For all types of cylinder the materials shall be the same specification, have the same nominal thickness and the same manufacturing processes as the production cylinders.

For cylinders with over-moulding or with a protective casing, the over-moulding or protective casing design and material shall be the same as used for the production cylinders.

8.2.2 3 cylinders shall be selected for a fatigue test in accordance with 7.5.2 when so required by 5.4, 5.6.2, 6.8.2 or 6.8.3.

8.2.3 2 cylinders shall be selected for mechanical tests in accordance with 7.3.5 and 7.3.6. 2 cylinders shall be selected for radiographic/macro tests in accordance with 7.4.1 and 7.4.2.

8.2.4 2 cylinders shall be selected for a burst test in accordance with 7.5.1.

8.2.5 2 cylinders shall be subject to:

- dimensional and wall thickness checks to confirm compliance with the design;
- tolerance checks to confirm compliance with the requirements of 6.6; and
- visual examination of the surface of the welds, in accordance with 7.4.3,

NOTE These can be the same cylinders used for the mechanical tests and where practicable cylinders can be subject to more than one test.

8.2.6 The vacuum resistance of cylinders intended to contain LPG with a vapour pressure not exceeding 16 bar absolute at 70 °C, shall be checked by calculation or tests. The minimum allowable pressure shall be 0,6 bar absolute unless a higher vacuum requirement is specified for operational reasons.

NOTE An acceptable calculation method is given in EN 13445-3.

8.2.7 The resistance to external corrosion tests shall be carried out in accordance with 7.3.7.

NOTE The resistance to external corrosion tests are not required for stainless steel hot air balloon cylinders.

8.2.8 The impact resistance tests shall be carried out in accordance with 7.5.3.

8.2.9 The drop tests shall be carried out in accordance with 7.5.4 or 7.5.5 (as appropriate).

8.3 Design type variations

8.3.1 General

The design type specification may include the following parameters for which the type test results are also valid and which will be covered by the design type approval

8.3.2 Two piece cylinders

8.3.2.1 Different designs of cylinder shall be considered to be of the same type when the following characteristics are the same:

- nominal diameter;
- nominal end profile;
- minimum thickness; and
- material specifications.

8.3.2.2 In addition to 8.3.2.1, different designs of cylinder shall be considered to be of the same type when the cylinders are:

- of a length not greater than the length of the cylinders used for type approval testing;
- equipped with the same openings (see 5.6);
- manufactured using the same manufacturing techniques;
- subject to the same heat treatment conditions; and
- manufactured using the same type of mechanised or automatic welding machines.

8.3.3 Three piece cylinders

8.3.3.1 Different designs of cylinder shall be considered to be of the same type when the following characteristics are the same:

- nominal diameter;
- nominal end profile;
- minimum thickness; and
- material specifications.

8.3.3.2 In addition to 8.3.2.1 different designs of cylinder shall be considered to be of the same type when the cylinders are:

- of a length not greater than the length of the cylinders used for type approval testing;
- equipped with the same openings (see 5.6);

- manufactured using the same manufacturing techniques;
- subject to the same heat treatment conditions; and
- manufactured using the same type of mechanised or automatic welding machines.

8.3.3.3 In addition to 8.3.3.1 and 8.3.3.2, different designs of cylinder shall be considered to be of the same type when the:

- the length of the pressure envelope is not less than three times the outside diameter; and
- the length of the pressure envelope is not less than 0,67 times that of the cylinder type tested.

9 Initial inspection and tests

9.1 Tests and examinations applicable to all cylinders

9.1.1 All cylinders shall be subject to a visual examination of the longitudinal weld from both sides before the cylinder is closed in accordance with 6.5.4.

9.1.2 All finished production cylinders, prior to surface treatment, shall be subject to the following:

- a pressure test as specified in 9.7;
- a visual examination of the surface of the welds as specified in 7.4.3;
- an inspection of the markings as specified in Clause 10 and Annex A; and
- an inspection (visual and gauge) of the neck threads.

9.2 Radiographic examination

9.2.1 Radiography shall be carried out on the circumferential and longitudinal welds (see Figure 9 and Figure 10) of the first production cylinder in the following circumstances:

- at start of production,
- after a change in the type or size of cylinder,
- after a change in the welding procedure (including machine setting), or
- after a break in production exceeding 4 h.

9.2.2 In the case of cylinders outside diameter less than 250 mm, radiography of joggle joints may be replaced by two macro examinations (see 7.4.2), one of which shall be at the stop/start area and the other on the opposite side of the cylinder.

9.2.3 In addition to the requirements of 9.2.1 for cylinders with longitudinal welds, one cylinder out of every 250 production cylinders shall have the junction of the longitudinal and circumferential welds radiographed as indicated in Figure 11.

9.2.4 Where more than one welding machine is used for production, the above procedures shall apply to each such machine.

9.3 Macro examination

9.3.1 Macro examination shall be carried out on the circumferential welds of sample cylinders as detailed in Table 3 and Table 4. The sample cylinders shall be selected in accordance with 9.8.

9.3.2 Macro examination shall be carried out as specified in 7.4.2.

9.4 Examination of bung welding

Radiographic or macro examination shall be carried out at sampling rates and on samples taken from cylinders selected for the mechanical/burst tests as specified in 9.8.

9.5 Examination of welding of non-pressure containing attachments

9.5.1 Macro examinations

For cylinders where the attachments are welded before closure of the cylinder and visual examination has been carried out to check the evidence of excess penetration, one cylinder at the beginning of each production shift shall be tested.

For cylinders where visual examination for excess penetration has not been carried out, one cylinder out of every thousand cylinders produced, shall be tested.

For hot air balloon cylinders the examination of welding of non-pressure containing attachments, radiographic or macro examinations shall be carried out on at least one cylinder out of every two-hundred and fifty production cylinders.

The examination may be carried out on samples taken from cylinders selected for the mechanical/burst tests specified in 9.8.

The macro examination may be supplemented by radiographic examination at the manufacture’s discretion.

9.5.2 Weld penetration requirement

There shall be no evidence of excess penetration.

9.6 Unacceptable imperfections in radiographic or macro examination

9.6.1 If any of the radiographic or macro examinations show an unacceptable imperfection, production shall be stopped.

9.6.2 Every cylinder welded since the preceding acceptable radiographic or macro examination shall be set aside until it is demonstrated that these cylinders are satisfactory either by radiographic or macro examination or other appropriate means.

9.6.3 Production shall not be restarted until the cause of the defect has been established and rectified, and the relevant procedure as specified in 9.2 or 9.3 has been repeated.

Rejected parts and cylinders should be processed for recycling.

9.7 Production pressure test

9.7.1 Procedure

9.7.1.1 The test fluid shall normally be a liquid. A gas may be used provided that appropriate safety precautions are taken.

NOTE RID/ADR require that the use of a gas for the pressure test is agreed with the competent authority.

9.7.1.2 The minimum test pressure to be applied shall be as specified in 5.1.3.

9.7.1.3 The pressure in the cylinder shall be increased gradually until the test pressure is reached.

9.7.1.4 The cylinder shall remain under pressure long enough to establish that no leaks can be observed, but not less than 15 s.

9.7.2 Requirements

9.7.2.1 There shall be no leaks from the cylinder.

9.7.2.2 After the test the cylinder shall show no visible signs of permanent deformation.

9.7.2.3 Cylinders that do not pass the test shall be rejected.

The fluid used for the pressure test should be recycled for further use or disposed of with due regard to the environment.

Rejected cylinders should be processed for recycling.

9.8 Production batch testing (Mechanical / Burst tests)

9.8.1 Production batch

9.8.1.1 For all, except hot air balloon cylinders, a production batch shall consist of cylinders made consecutively by the same manufacturer, using the same manufacturing process, to the same design, size and material specifications, on the same type of automatic welding machines and subject to the same heat treatment conditions.

NOTE In this context, "consecutively" need not imply continuous production.

9.8.1.2 For hot air balloon cylinders a production batch shall consist of cylinders made consecutively by the same manufacturer using the same manufacturing technique, to the same design, size and material specifications on the same type of automatic welding machines. A production batch shall consist of not more than 250 cylinders.

NOTE In this context "consecutively" need not imply continuous production.

9.8.2 Inspection lots

For acceptance purposes the production batch shall be divided into inspection lots not exceeding 1 000 cylinders.

For selection of sample cylinders for either burst or mechanical tests, each lot is divided into sub-lots of 250 cylinders during the first 3 000 cylinders of a production batch and sub-lots of 500 cylinders or lots of 1 000 cylinders, depending on cylinder size, thereafter (see Figure 18 — Inspection lots)

9.8.3 Rate of sampling

9.8.3.1 General

Where a production batch contains material from more than one cast, the manufacturer shall arrange for samples tested to represent each cast of material used.

The reduced rate of sampling for large volume manufacture (above 3 000 cylinders) may only be applied once the manufacturer can demonstrate that the production batch production test results and manufacturing processes are consistently reliable without any major interruption of manufacture.

Except as permitted by 9.8.3.3.1, the samples taken for "Burst tests or Mechanical tests" shall be alternated between the mechanical and the burst tests.

9.8.3.2 Production batch less than or equal to 3 000 cylinders

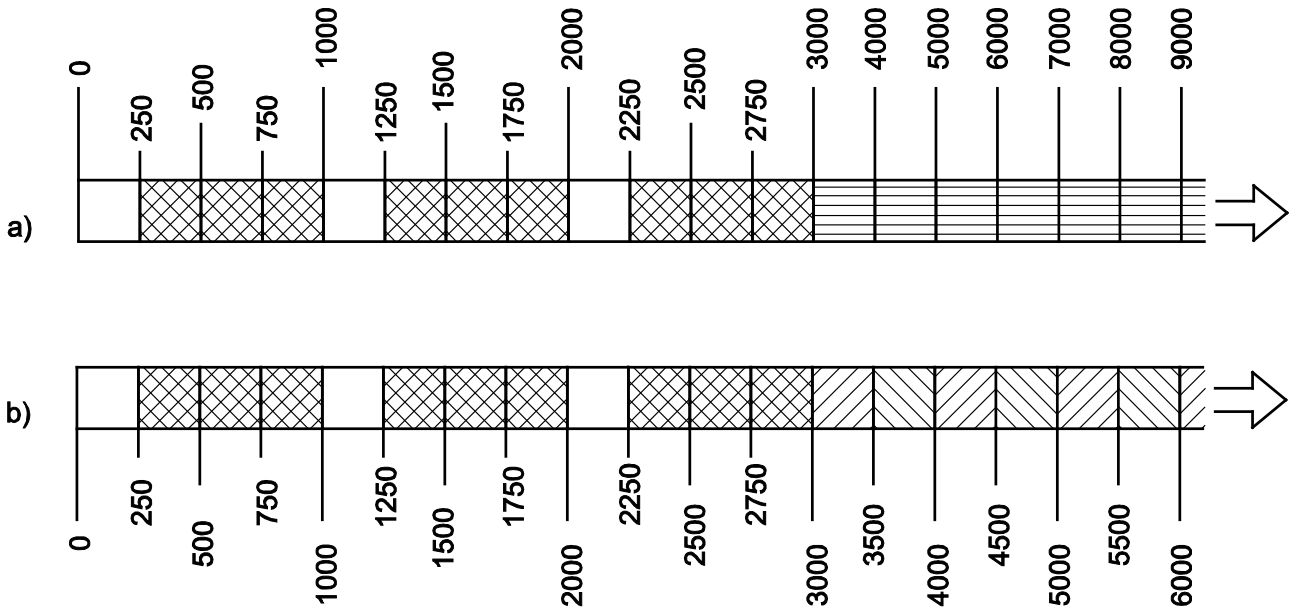
9.8.3.2.1 From the first 250 cylinders or less in each inspection lot, representative cylinders shall be taken at random, one for the burst test and one for mechanical tests.

9.8.3.2.2 From each subsequent group of 250 cylinders or less in the inspection lot, one representative cylinder shall be taken at random for either a burst test or mechanical tests.

9.8.3.3 Production batch over 3 000 cylinders

9.8.3.3.1 Cylinders less than or equal to 35 l capacity

For the first 3 000 cylinders in the production batch, representative cylinders shall be taken as specified in 9.8.3.2. From each inspection lot remaining, representative cylinders shall be taken at random, one for the burst test and one for mechanical tests.



Key

a) For cylinders of volume less than or equal to 35 l

b) For cylinders of volume greater than 35 l

Size of lot/sub-lot	Symbol	No. of cylinders	Type of tests
250		2	one subjected to a Burst test and one subjected to a Mechanical test.
250		1	one subjected to a Burst test or a Mechanical test.
500		2	one subjected to a Burst test and one subjected to a Mechanical test.
500		1	one subjected to a Burst test or a Mechanical test.
1 000		2	one subjected to a Burst test and one subjected to a Mechanical test.

Cylinders that have a water capacity less than 6,5 l and have a burst pressure of greater than 100 bar and are required by 9.7to be subject to mechanical tests, may, at the manufacturer's discretion, be subjected to the burst test as an alternative to the mechanical test.

Figure 18 — Inspection lots

9.8.3.3.2 Cylinders greater than 35 l capacity

9.8.3.3.2.1 For the first 3 000 cylinders in the production batch, representative cylinders shall be taken as specified in 9.8.3.2.

9.8.3.3.2.2 From the first 500 cylinders or less in each inspection lot remaining, representative cylinders shall be taken at random, one for the burst test and one for mechanical tests.

9.8.3.3.2.3 From the remaining 500 cylinders or less in such inspection lots (see 9.8.3.3.2.2), one representative cylinder shall be taken at random for either a burst test or mechanical tests.

9.8.3.3.3 Cylinders less than or equal to 6,5 l

For cylinders with a water capacity of less than or equal to 6,5 l and having a burst pressure greater than 100 bar, samples selected for mechanical tests may be subjected to a burst test as an alternative.

9.8.4 Verification of conformance with type approval

A minimum of one cylinder from each batch shall be checked to ensure that it fully conforms with the requirements of the type approval. If the cylinder does not conform, all cylinders from that batch shall be rejected until the non-conformance has been resolved.

NOTE This does not require all of the type approval tests to be repeated.

9.9 Failure to meet mechanical and burst test requirements

9.9.1 General

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

9.9.2 Mechanical

9.9.2.1 If there is evidence of a fault in carrying out the mechanical tests, or of an error of measurement, a second test on the same cylinder shall be performed. If the result of this test is satisfactory, the first test shall be ignored.

9.9.2.2 If the test confirms the initial test result, the procedure specified in 9.9.4.1 or 9.9.4.2 shall be followed.

9.9.3 Burst

In the event of a single cylinder failing the burst test, the procedure specified in 9.9.4.1 or 9.9.4.2 shall be followed.

9.9.4 Production batch retest

9.9.4.1 In the event of a single cylinder failing either the mechanical or burst test, both mechanical and burst tests shall be repeated as shown in Table 9, the retest cylinders shall be taken at random from the same lot/sub-lot.

In the event that there is no failure from the retest the production batch shall be accepted.

9.9.4.2 In the event of more than one cylinder failing the tests or one or more cylinders failing the retest specified in 9.9.3.1 the production batch shall be rejected.

Table 9 — Production batch retest requirements

Inspection lot/sub-lot size	Failure	Retest
≤250	1M	2M + 1B
≤250	1B	2B + 1M
> 250	1M	2M + 2B
> 250	1B	1M + 4B
NOTE M denotes mechanical test and B denotes burst test.		

9.9.5 Resubmission of production batch

9.9.5.1 Heat treated cylinders

In the case of heat treated cylinders, the manufacturer may:

- heat-treat the rejected production batch, or

- repair any weld defects and heat-treat the production batch.

The production batch may then be resubmitted as a new production batch as specified in 9.8.

9.9.5.2 Non heat-treated cylinders

In the case of non heat-treated cylinders the production batch may be heat-treated and resubmitted provided that further type approval tests are carried out and the weld procedures are qualified to establish the suitability of the heat treatment.

9.9.6 Additional checks

The sample cylinders selected for mechanical test shall also undergo the following checks;

- dimensional and wall thickness checks to confirm compliance with the design; and

- tolerance checks to confirm compliance with the requirements of 6.6.

Following the tests; all cylinders that are rejected or are not being retained (for record purposes) should be processed for recycling.

9.10 Production adhesion test for over-moulded cylinders

Production testing for the adhesion of the over-moulded case shall be undertaken by the manufacturer that applies the over-moulded protective case.

The testing shall be carried out in accordance with 7.3.7.3.2 and the test acceptance values shall be in accordance with Table 10.

The production test for adhesion of protecting material on coating shall be carried out on one over-moulded cylinder every 1 000 cylinders produced.

In the event of the cylinder failing the test, the test shall be repeated on two additional cylinders.

In the event of one or more of the cylinders failing the retest the production batch shall be rejected.

Table 10 — Resistance to external corrosion production test for over-moulded cylinders

Test type	Test details	Acceptance value
Adhesion of protecting material on coating test	5 pull-off tests at mid height (on the sides) every 90° and on the bottom as illustrated in Figure 11 See procedure in 7.3.7.3.2	Breaking strength > 1 MPa per test. Breaking shall occur into the protecting material layer or between the protecting material and the adhesive.

9.11 Production water absorption test for over-moulded cylinders

9.11.1 The production testing for the water absorption of the over-moulding shall be undertaken by the manufacturer that applies the over-moulding.

9.11.2 The testing shall be carried out in accordance with 7.3.7.3.4 and the test acceptance values shall be in accordance with Table 11.

9.11.3 The production test shall be carried out on one over-moulded cylinder for every 1 000 cylinders produced.

9.11.4 In the event of the cylinder failing the test, the test shall be repeated on two additional cylinders.

In the event of one or more of these cylinders failing the retest the production batch shall be rejected.

Table 11 — Production water absorption test for over-moulded cylinders

Test type	Test details	Acceptance value
Water absorption	See 7.3.7.3.4	Shall not absorb more than 0,05 grams of water per gram (5 % by mass) of the cellular plastic coating material

10 Marking

10.1 Each cylinder shall be marked clearly and legibly with certification, manufacturing and operational information in accordance with EN 14894 and Annex A.

10.2 The over-moulding case shall not cover the cylinder serial number and if the other permanent marks are covered by the over-moulding they shall be moulded into the over-moulding or on a plate entrained within the over-moulding. Where a separate plate is used it shall also be marked with the cylinder serial number.

10.3 Each over-moulded cylinder shall be fitted with an individual resilient identification electronic tag or an equivalent device linked to an electronic database.

10.4 For over-moulded cylinders a technology database shall be established and maintained by the owner or operating company of the cylinders with shall allow:

- to trace the specific technical characteristics of the cylinders;

- to accurately operate each cylinder (including tare mass);

- to ensure the mandatory monitoring of the cylinders;

- to automatically withdraw a batch of cylinders to perform tests and/or to manage the periodic inspection test date;

- to carry out the marking which indicates the successful completion of the periodic inspection;

- to look for the history of all the events during the cylinders life.

10.5 Cylinders designed for use in hot air balloons shall be marked “for use in hot air balloons only”.

10.6 Where the marking is directly on the surface of the steel cylinder, it shall be demonstrated by the fatigue and burst tests that failure does not initiate in the markings and the markings remain legible.

NOTE The marking of cylinders is regulated by RID/ADR which takes precedence over any clause in this European Standard. The European Directive on Transportable Pressure Equipment 2010/35/EU [13] includes additional marking requirements (π-marking).

Any packaging and protection used during storage/transport of the finished products should be selected to have the minimum environmental impact, i.e. use of recyclable or bio-degradable materials, minimum use of energy.

10.7 The database shall be operated by the cylinder owner or operating company and should be capable of recording the following:

(a) the identification details of each cylinder;

(b) the manufacturing information of each cylinder;

(c) the status of each cylinder regarding periodic inspection;

(d) the tare mass of each cylinder; and

(e) information to allow identified cylinders or production batches to be segregated for any purposes (e.g.periodic inspection, sampling).

10.8 Procedures shall be applied to prevent water ingress into the cylinder between the production of the coated cylinder and the over-moulding of the protection material on the coated pressure receptacle.

11 Documentation

All testing and approvals shall be documented.

12 Certification

Each batch of cylinders shall be covered by a certificate stating that the cylinders meet the requirements of this European Standard and the approved design type specification in all respects.

For cylinders with over-moulding or protective casings, the design and materials of the protective over-moulding or casing shall be recorded on the type approval certificate.

For cylinders with over-moulding casings, if the over-moulding is painted it should be recorded in the technical specification and in the type approval certificate.

Annex A
(normative)

Additional manufacturers markings

In addition to EN 14894 the markings in Table A.1 shall be applied per Clause 10.

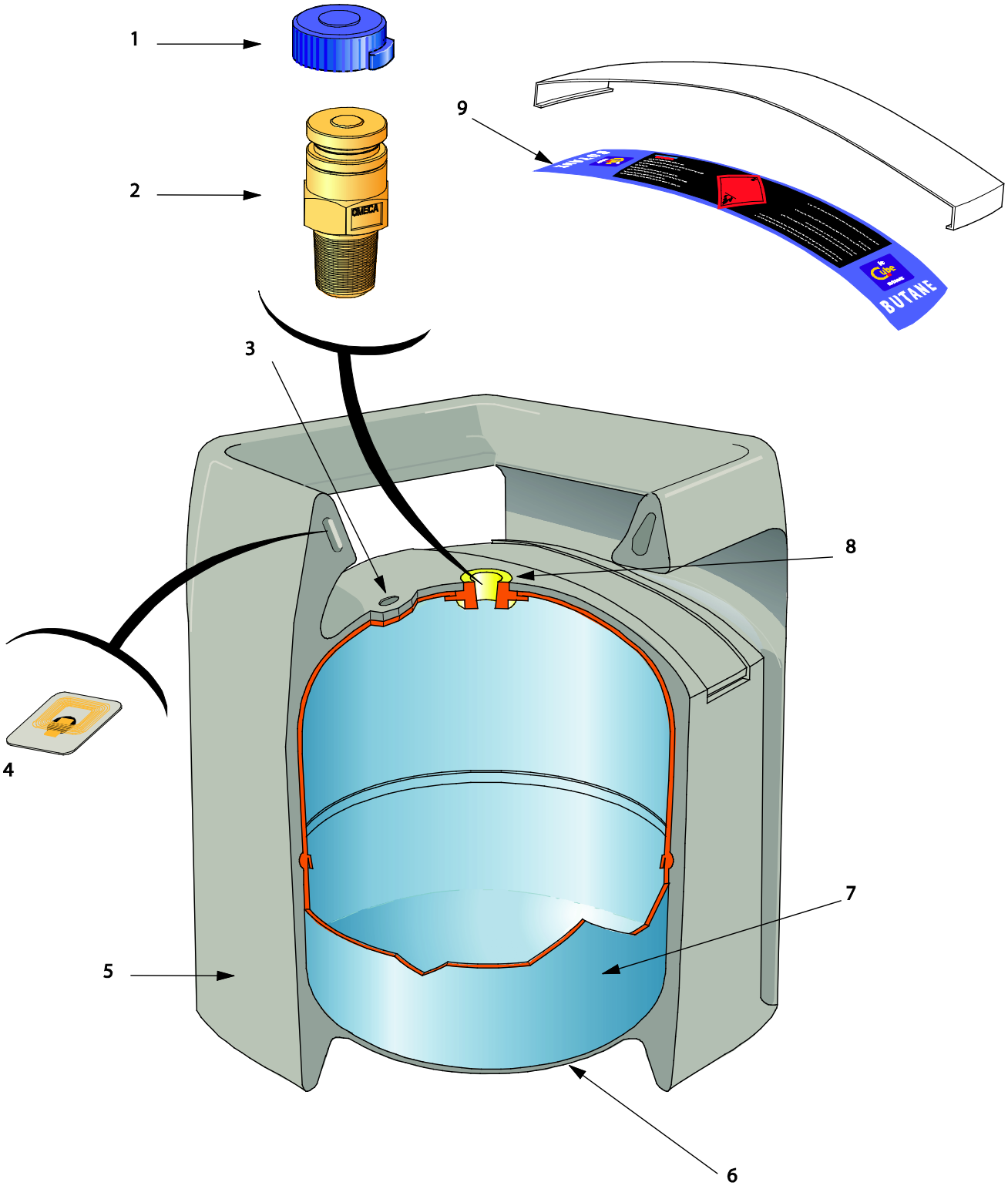
Table A.1 — Manufacturers marking

Definitions	Example
For a cylinder which is normalised, this symbol shall be placed immediately after the European Standard number.	N
For a cylinder which is stress relieved, this symbol shall be placed immediately after the European Standard number.	S
For a cylinder which is not normalised or stress relieved, this symbol shall be placed immediately after the European Standard number.	U
The volumetric expansion, where required by 7.5.1.2.2.2.	8 % EXP

Annex B
(informative)

Over-moulded cylinder

An example of an over-moulded cylinder is given in Figure B.1.



Key

1	cylinder valve cap	**6**	certification, operational and manufacturing marks
2	cylinder valve	**7**	coated steel inner pressure receptacle
3	tare weight indication	**8**	cylinder number
4	electronic identification tag	**9**	identification marks and transport label
5	over-moulded case		

Figure B.1 — Example of an over-moulded cylinder

Annex C
(informative)

Hot Air Balloon Cylinders

C.1 Description

An example of a hot air balloon cylinder is given in Figure C.1.

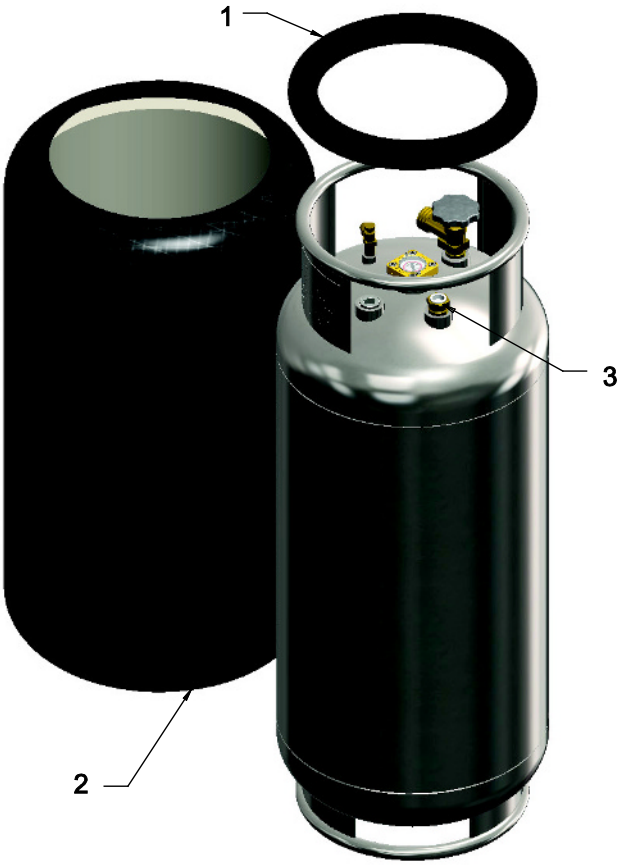
Cylinders are manufactured out of high strength (Duplex) stainless steel or cold formed austenitic steels (typical water capacity 40-95 l).

Their design and construction for their primary purpose is approved under Commission Regulation (EU) No 748/2012, Annex Part 21 lays down the implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations. The Certification Specification under this regulation requires that the design and construction shall also consider the effects of recurrent and other loads experienced during ground handling and transportation.

The design of the cylinder is optimised for the conditions to which they will be subjected during their normal conditions of carriage and use (RID/ADR Clause 6.2.1.1.1). Their wall thickness meets the calculated values for pressure, fatigue and manual handling of this standard, but does not include additional allowances for industrial transportation.

In addition to inspection at the time of filling and periodic testing, the cylinders are inspected annually by a competent person in accordance with Commission Regulation (EC) No 2042/2003 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

The cylinders are transported in small quantities (typically 3-6 cylinders) secured within the balloon basket (or gondola) within vans, pickup trucks or small trailers. There is no normal requirement to transport these cylinders on large goods vehicles. If cylinders are to be transported, whilst gas charged, on large goods vehicles they shall be transported within additional protection and secured in such a way that additional protection is not required.



Key

1 valve protection ring (structural foam) – Removable

2 protective sleeve (structural foam) - Removable

3 pressure relief valve

Figure C.1 — Typical hot air balloon cylinder

Annex D
(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	4.8	4.8 6.1 6.4	5.1.5 6.1 6.4 9.9.5	10		5.1.5	5.1.5	5.1.5			
Water			7.5.1.2.3 9.7.2.3								
Energy	4.8	4.8	5.1.5 6.1 6.4 6.8.4	4.8 10							5.1.5
Land					5.1.5						
Outputs											
Emissions to air			4.12								5.1.5
Discharges to water			7.5.1.2.3 9.7.2.3								
Discharges to soil											
Waste			5.1.5 6.1 6.4 7.5.1 7.5.4.2 7.5.5.2 9.6 9.7.2.3 9.9.5	10				5.1.5 6.1 6.4 7.5.1 7.5.4.2 7.5.5.2 9.6 9.7.2.3 9.9.5			5.1.5
Noise, vibration, radiation, heat losses			6.1 6.4 6.8								5.1.5

Other relevant aspects											
Risk to the environment from accidents or unintended use			Intro 1		11						
Customer information					11						
Comments:											

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