BS EN 12807:2009

LPG equipment and accessories — Transportable refillable brazed steel cylinders for liquefied petroleum gas (LPG) — Design and construction

ICS 23.020.30; 75.200

National foreword

This British Standard is the UK implementation of EN 12807:2009. It supersedes BS EN 12807:2001 which is withdrawn.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.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Equipement et accessoires pour GPL - Bouteilles transportables et rechargeables en acier brasé pour gaz de pétrole liquéfié (GPL) - Conception et fabrication

Flüssiggas-Geräte und Ausrüstungsteile - Ortsbewegliche, wiederbefüllbare, hartgelötete Flaschen aus Stahl für Flüssiggas (LPG) - Konstruktion und Herstellung

This European Standard was approved by CEN on 14 May 2009.

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Foreword

This document (EN 12807:2009) has been prepared by Technical Committee CEN/TC 286 “Liquefied petroleum gas equipment and accessories”, the secretariat of which is held by NSAI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

This document supersedes EN 12807:2001.

The main technical changes are a widening of the range of materials permitted, reference to the latest EN brazing standards, a reduction in the minimum required burst pressure from 50 bar to 35 bar and simplification of the marking requirements by reference to EN 14894.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

This European Standard has been submitted for reference into the RID and/or in the technical annexes of the ADR.

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Introduction

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

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

All pressures are gauge unless otherwise stated.

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

1 Scope

This European Standard specifies the minimum requirements for the design, construction and testing during manufacture of transportable refillable brazed steel Liquefied Petroleum Gas (LPG) cylinders, of water capacity from 0,5 l up to and including 15 l, exposed to ambient temperatures.

This European Standard applies only to cylinders having a circular cross-section without any longitudinal joint.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1044, *Brazing – Filler metals*

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

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

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

EN 12797, *Brazing – Destructive tests of brazed joints*

EN 12799:2000, *Brazing – Non-destructive examination of brazed joints*

EN 13134, *Brazing – Procedure approval*

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

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

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
yield strength
upper yield strength R_{eH} or 0,2 % proof strength (non-proportional elongation), $R_{p0,2}$, for steels that do not exhibit a defined yield

3.1.2
normalised
heated to a uniform temperature above the upper critical point (Ac_3) of the steel and then cooled under controlled conditions in still air

3.2 Symbols

a Calculated thickness of the cylindrical shell, in millimetres

A Percentage elongation after fracture

b Calculated thickness of the end of the cylinder, in millimetres

C Shape factor for ends (see Table 2, Figure 2 and Figure 3)

D Outside diameter of the cylinder as given in the design drawing (see Figure 1), in millimetres

D_p Width of the bend test mandrel (see Figure 7), in millimetres

e Actual thickness of the material in the finished cylinder (at the point under consideration), in millimetres

h Height of the cylindrical part of the end (see Figure 1), in millimetres

H Outside height of the domed part of the end (see Figure 1), in millimetres

L_O Original gauge length of the test piece, in accordance with EN 10002-1, in millimetres

n Ratio of width of bend test mandrel to the thickness of the test piece at the joint (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

r Inside knuckle radius of the torispherical end, in millimetres

R Inside spherical radius of the torispherical end, in millimetres

R_g Minimum value of tensile strength guaranteed by the cylinder manufacturer for the finished cylinder, in newtons per square millimetre

R_o Minimum value of yield strength guaranteed by the cylinder manufacturer for the finished cylinder, in newtons per square millimetre

R_m Actual value of tensile strength determined by the tensile test specified in 7.4, in newtons per square millimetre

R_{eH} Upper yield strength, in newtons per square millimetre, as defined in EN 10002-1

$R_{p0,2}$ Proof strength, non proportional extension in newtons per square millimetre, as defined in EN 10002-1

t Thickness of the bend test specimen at the joint

4 Materials

4.1 Materials for shells and end pressings shall be in accordance with EN 10120 or other equivalent material specification or standard meeting the requirements of Table 1. Alternative material specifications shall, as a minimum, specify chemical composition, mechanical properties, heat treatment and delivery conditions.

The materials shall be suitable for a brazing temperature of 1 100 ˚C for the duration of the brazing operation, without significant grain growth.

NOTE "Materials" refer to materials in the state before any specific transformation occurring during the manufacturing process.

4.2 All parts brazed to the cylinder shall be brazable and made of material compatible with the cylinder material.

4.3 The brazing consumables (see EN 1044) in the form of wire or paste shall be such that they are capable of giving consistent joints with minimum tensile strength at least equal to that specified for the parent materials in the finished cylinder.

4.4 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/reports shall be in accordance with EN 10204:2004, Type 3.1 or higher for shells and ends and Type 2.2 or higher for the valve boss.

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

Table 1 — Material requirements

Element	Limits %
Materials, other than EN 10120, used for the fabrication of cylinders shall be of brazable quality and the following limits shall not be exceeded in the cast analysis:	
Carbon	0,22 max.
Silicon	0,50 max.
Manganese	0,30 min. to 1,60 max.
Phosphorus	0,025 max.
Sulphur	0,020 max.
Phosphorus plus sulphur	0,040 max.
Use of micro-alloying elements such as niobium, titanium and vanadium shall be limited to the following contents:	
Niobium	0,05 max.
Titanium	0,05 max.
Vanadium	0,05 max.
Niobium plus vanadium	0,08 max.
Where other micro-alloying elements are used, their presence and amounts shall be reported, together with the above, in the steel manufacturer's certificate. Should check analyses be required, they shall be carried out either on specimens taken during manufacture from material in the form as supplied by the steel maker to the cylinder manufacturer or from finished cylinders.	

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 not less than the higher of:

— absolute developed pressure at 65 °C of the highest pressure LPG mixture to be filled minus 1 bar, or

— 10 bar.

NOTE ADR [5] and RID [6], P200 specifies test pressures for tabulated mixtures of LPG (UN 1965 HYDROCARBON GAS MIXTURE LIQUEFIED, N.O.S) irrespective of the absolute pressure at 65 °C.

5.1.4 A drawing, which includes full dimensions that define the cylinder type (see 8.2) and the specification of the material, shall be produced.

5.2 Calculation of cylindrical shell thickness

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

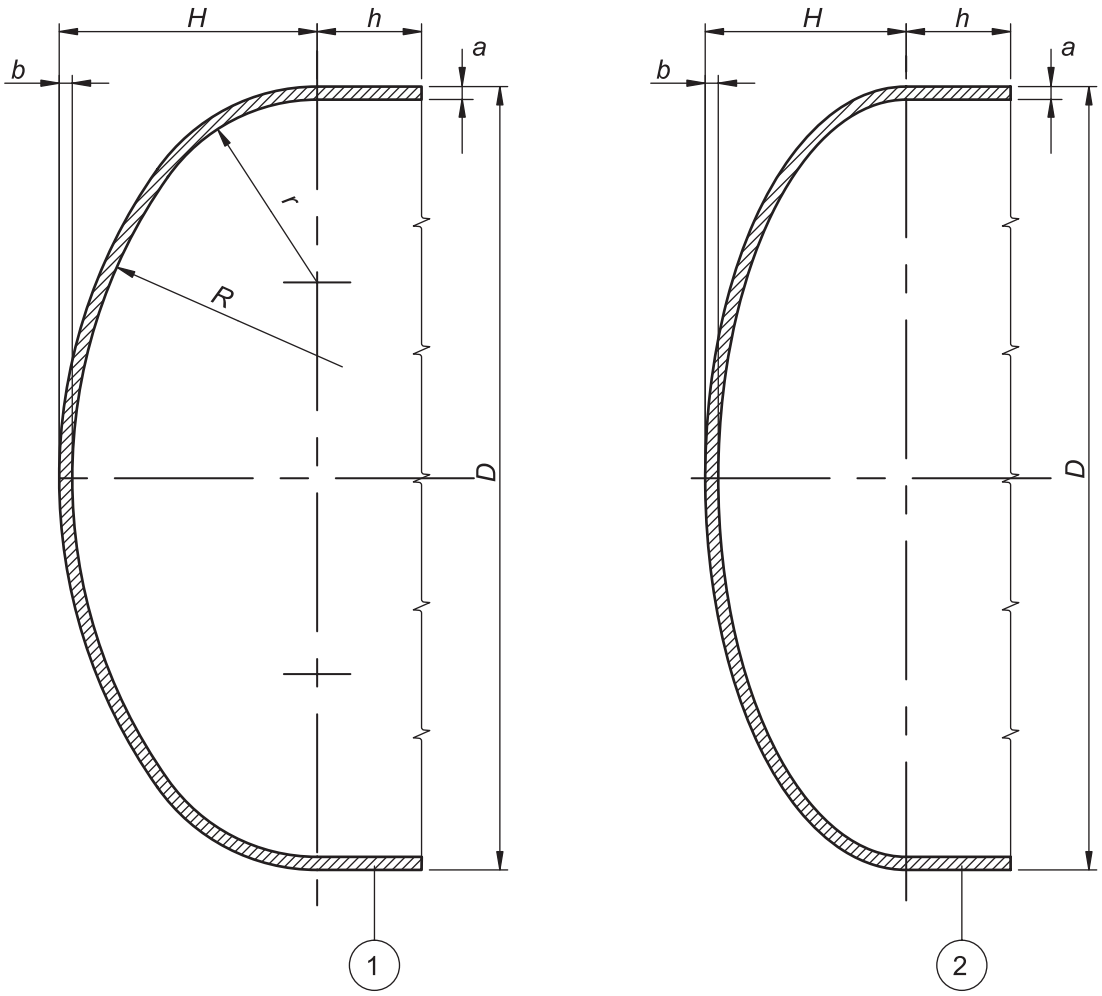
$$a = \frac{P_c \times D}{(15 \times R_o) + P_c}$$

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 $R \leq D$; $r \geq 0{,}1\ D$; $h \geq 4\ b$ (see Figure 1),

— for semi-ellipsoidal ends $H \geq 0{,}2\ D$; $h \geq 4\ b$ (see Figure 1).



Key

1 Torispherical end
2 Semi-ellipsoidal end

Figure 1 — Illustration of cylinder ends concave to pressure

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

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

5.3.2 The wall thickness, *a,* of any cylindrical part shall be calculated in accordance with 5.2.

This requirement is not applicable where the length of the cylindrical portion of the cylinder, measured between the beginning of the domed parts of the two ends, is not more than $\sqrt{2bD}$. In this case the wall thickness shall be not less than that of the domed part.

The thickness, *b,* of the domed part 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*.

The value of *C* shall be obtained from Figure 2 or Figure 3/Table 2.

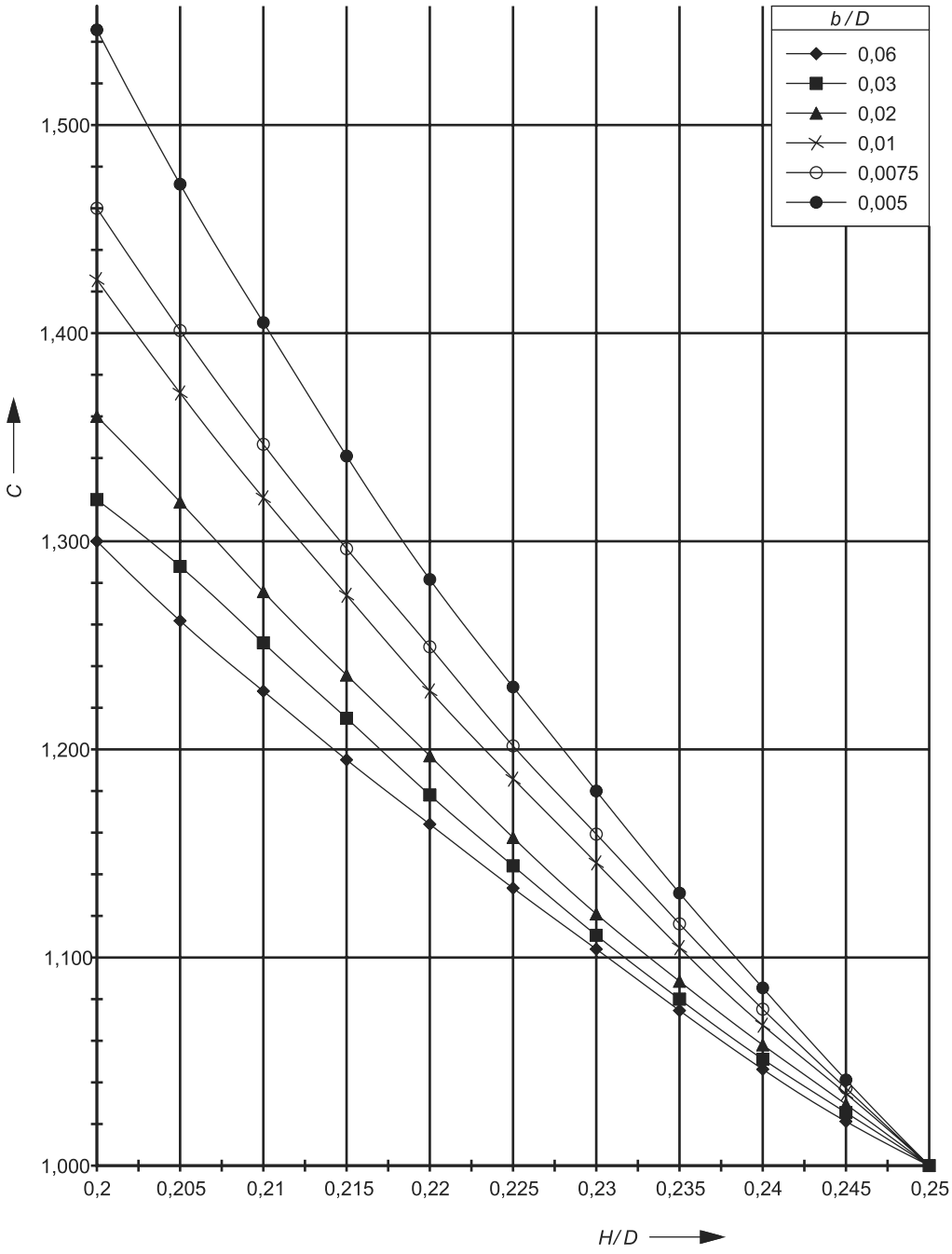


Figure 2 — Values of shape factor *C* for *H/D* between 0,2 and 0,25

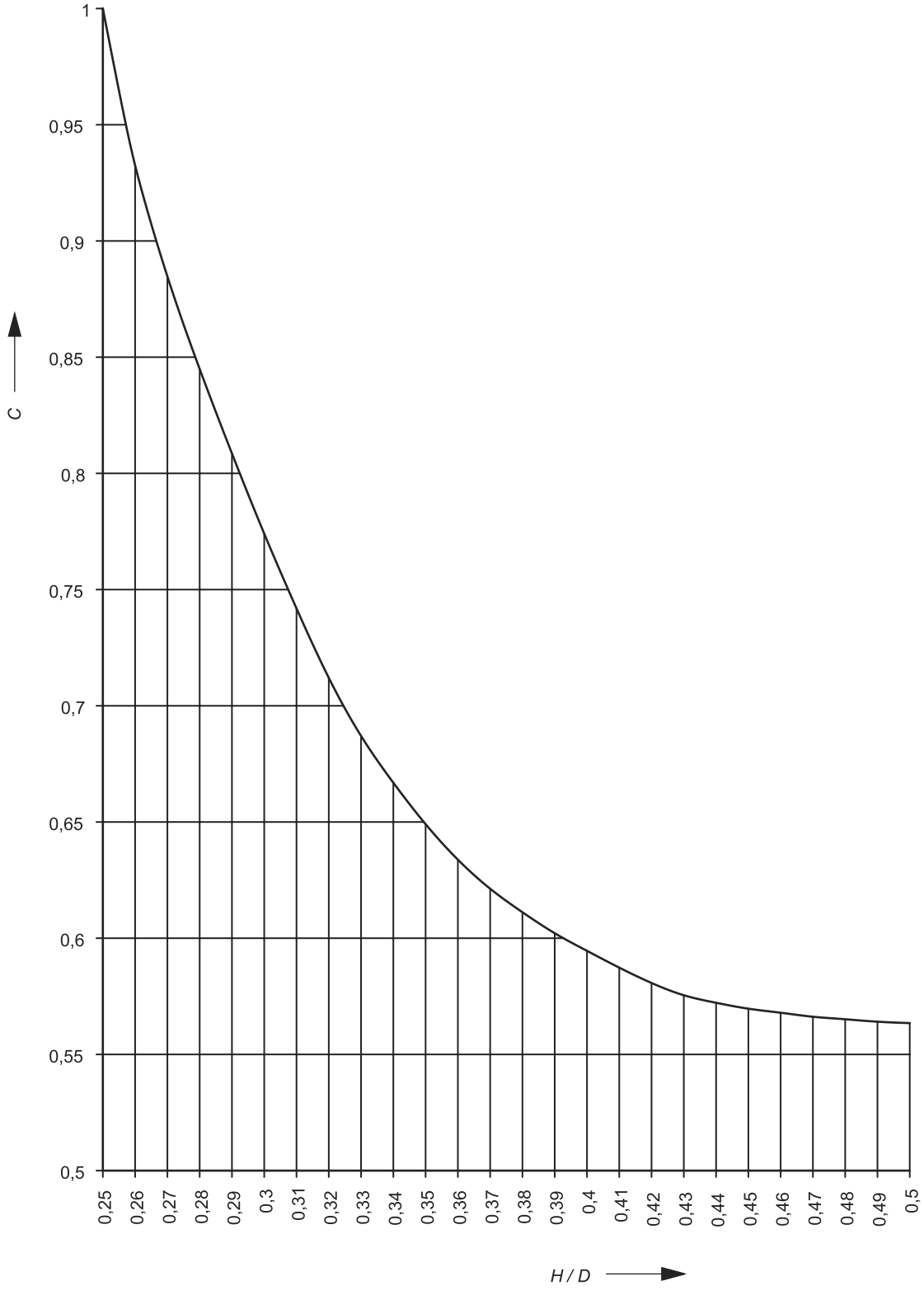


Figure 3 — Values of shape factor *C* for *H/D* between 0,25 and 0,5

Table 2 — 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 Design of ends of shapes other than torispherical and semi-ellipsoidal

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 7.11 or by appropriate stress analysis. For ends convex to pressure, the minimum end thickness shall be not less than 2 times that required by 5.2.

5.5 Minimum wall thickness

The minimum wall thickness of the cylindrical shell and ends shall be not less than the greater of:

— the values of *a* and *b* determined in accordance with 5.2 and 5.3 or 5.4, as appropriate, or

— the following values, as appropriate:

for $D < 100$ mm:
1,1 mm

for 100 mm $\leq D \leq$ 150 mm:
[1,1 + 0,008 (D - 100)] mm

for $D > 150$ mm:
$[\frac{D}{250} + 0,7]$ mm, but not less than 1,5 mm.

These formulae apply to cylindrical shells and ends irrespective of whether they are designed by calculation as specified in 5.2 and 5.3 or by testing as specified in 5.4.

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 brazing. 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 7.11.

5.6.3 The joints 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 an established dimensional specification.

NOTE Suitable thread specifications include ISO 10920 for 25E thread and EN ISO 11116-1 for the 17E thread.

5.7 Valve protection

The design of a cylinder shall provide protection for valves against damage in order to avoid the release of the contents, unless the valve is protected by other means.

When the valve protection is integral with the cylinder, this shall be demonstrated by drop testing in accordance with EN ISO 11117:2008, Clause 6.7.

NOTE 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 cylinder should be fitted with valves that have demonstrated, by impact tests in accordance with EN 13152 or EN 13153, that the valve can withstand damage without leakage of the contents.

5.8 Non-pressure containing attachments

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

5.8.2 Where a foot-ring 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 joints. Any foot-ring shall be suitably drained and the space enclosed by the foot-ring suitably ventilated e.g. by means of openings.

6 Construction and workmanship

NOTE ADR [5] and RID [6] require the manufacturing process to be subject to a survey by the relevant body to ensure the product is produced in conformity with the provisions of the type approval.

6.1 Brazing qualification

6.1.1 Brazing associated with the pressure envelope including non pressure-containing parts shall:

— have a brazing procedure specification for all joints, qualified in accordance with EN 13134;

— be done by brazers qualified in accordance with EN 1044.

The manufacturer shall maintain records of such procedures, qualifications and approvals.

6.1.2 Brazing procedure approval tests shall be on joints that are representative of those made in production.

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

6.2 Plates and pressed parts

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

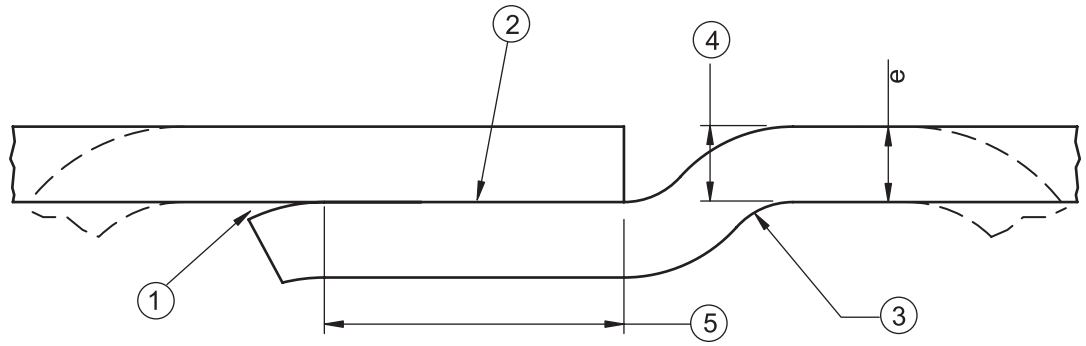
6.3 Brazed joints

6.3.1 The strength characteristics of the joints in the finished cylinder shall fulfil all requirements for the design and calculation of the cylinder.

6.3.2 The brazing material shall penetrate through the joint as specified in Figure 4 and fill it sufficiently.

NOTE This may be achieved by placing the brazing filling metal above the joint before brazing, as illustrated in Figure 4.

6.3.3 There shall be no more than two circumferential joints, excluding the valve boss joint. These shall be joggled type having an overlap of at least four times the wall thickness, *e,* in accordance with Figure 4.



Key

1 The brazing material to be placed here before brazing
2 Brazing filler
3 Avoid sharp break
4 Depth of off-set to give a close fit on the mating part
5 Minimum contact length: 4 *e*

Figure 4 — Example of a typical circumferential joggled butt-joint

6.4 Tolerances

6.4.1 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. The measurement shall not be taken over any circumferential joints.

6.4.2 Straightness

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

6.4.3 Verticality

When the cylinder is standing on its base, the cylindrical shell and the axis of the top opening shall be vertical to within 1,5° (approximately 26 mm per metre of height).

6.5 Heat treatment

6.5.1 Cylinders shall be delivered in the normalised condition.

6.5.2 The cylinder manufacturer shall maintain records of heat treatment carried out to confirm that cylinders have been normalised simultaneously with brazing in the furnace.

6.5.3 Localised heat treatment shall not be permitted.

6.6 Protective coating

An external protective coating system of appropriate quality shall be applied to protect the bimetallic joint from exposure to corrosive media.

6.7 Closure of openings

Openings in finished cylinders shall be either:

— fitted with a plug of suitable non-absorbent material, or

— fitted with the appropriate valve or fitting,

to protect the thread from damage and to minimise entry of moisture into the cylinder.

7 Tests and examinations

7.1 General

Cylinders built according to this standard are subject to the conformity assessment system outlined in Clauses 7 and 8, consisting of the testing and approval of the design type, the supervision of the manufacture in combination with the initial inspection and testing of batches and all cylinders manufactured according to the design type.

NOTE Detailed regulations on the conformity assessment system and the approval for manufacture of pressure receptacles are outlined in ADR [5] and RID [6].

7.2 Types of test and evaluation of the test results

The tests and examinations to be applied to cylinders shall be in accordance with Clause 8 and Clause 9. This is illustrated in Table 3.

NOTE 1 Production tests are called "initial inspection and test" in ADR [5] and RID [6].

NOTE 2 ADR/RID require that the type tests and examinations be performed by the competent authority, its delegate or by an accredited inspection body and that this body shall issue a type-examination report upon completion of the tests and examinations.

Table 3 — Applicability of tests/examinations

Test/Examination		Clause	Type test		Production test	
				Specified in clause		Specified in clause
Material	Tensile	7.4	X	8.1 b)	X	9.7, 9.8
	Bend	7.5	X	8.1 b)	X	9.7, 9.8
Burst		7.6	X	8.1 c)	X	9.7, 9.8
Pressure		7.7	-	-	X	9.1.1
Ultrasonic		7.8	O	8.1 b)	O X Y	9.2.2, 9.5 9.2.1, 9.2.3 9.6.2
Macro		7.9	O	8.1 b)	O X Y	9.2.2 9.3.1, 9.4, 9.5 9.6.2
Visual		7.10	X	8.1 d)	X	9.1
Fatigue		7.11	X	8.1 a)	-	-

O This allows for an option of ultrasonic **or** macro.
X No option permitted – test to be performed.
Y Retest required under certain circumstances.

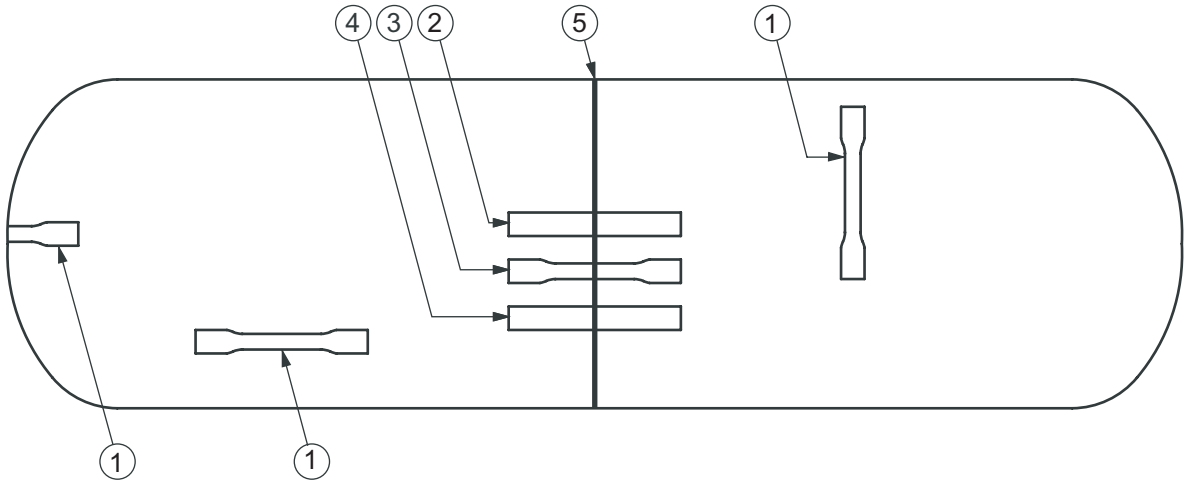
7.3 Material testing

7.3.1 The mechanical tests and the macro examination for checking the properties of the parent metal and joints 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 shall be in accordance with 7.3.

The test specimens detailed in Table 4 shall be taken from the places shown in Figure 5. Test pieces that are not sufficiently flat, shall be flattened by cold pressing.

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

Type	In accordance with	Key (see Figure 5)	Details
1 tensile test	EN 10002-1	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 12797	2	On the topside of the circumferential joint.
1 tensile test	EN 12797	3	Perpendicular to the circumferential joint.
1 bend test	EN 12797	4	On the underside of the circumferential joint.
1 macro examination	EN 12797	None	On a randomly selected location on the circumferential joint.



Key

1 Alternative locations of test specimen for tensile test
2 Test specimen for bend test (topside of the joint)
3 Test specimen for cross-joint tensile test
4 Test specimen for bend test (underside of the joint)
5 Circumferential joint

Figure 5 — Location of test specimens for mechanical testing

7.3.2 Valve boss joints

The brazing of the valve boss shall be checked by macro examination in accordance with 7.9.

7.4 Tensile test

7.4.1 Parent material

7.4.1.1 Procedure

The preparation of test specimens and procedure for carrying out the tensile test shall be in accordance with EN 10002-1.

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

7.4.1.2 Requirements

The values obtained for yield strength (R_{eH} or $R_{p0,2}$), tensile strength (R_m) and elongation (A) shall be not less than those guaranteed by the cylinder manufacturer in the finished cylinder (R_o, R_g and A).

7.4.2 Joints

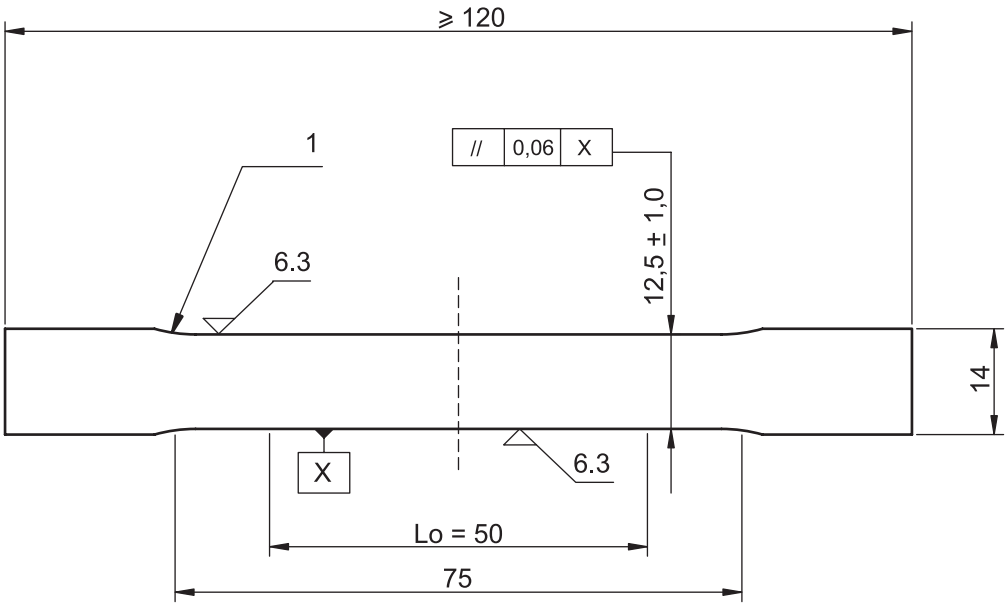
7.4.2.1 Procedure

The tensile test perpendicular to the joint shall be carried out in accordance with EN 12797 on a test specimen complying with Figure 6.

7.4.2.2 Requirements

The tensile strength value obtained, R_m, shall not be less than that guaranteed by the cylinder manufacturer R_g, irrespective of where the fracture occurs in the cross section of the central part of the test specimen.

Dimensions in millimetres



Key

1 Radius ≥ 20

Figure 6 — Test specimen for tensile test perpendicular to the joint

7.5 Bend test

7.5.1 Procedure

7.5.1.1 The preparation of test specimens and the procedure for carrying out the bend test shall be in accordance with EN 12797 and Figure 7.

7.5.1.2 The bend test specimens shall be 25 mm in width. A mandrel shall be placed in the centre of the joint while the test is being performed.

7.5.1.3 The specimen shall be fully bent round the mandrel as shown in Figure 7 b).

7.5.1.4 The ratio n between the width of the mandrel, D_p, and the thickness of the test specimen at the joint, t, shall not exceed the values given in Table 5.

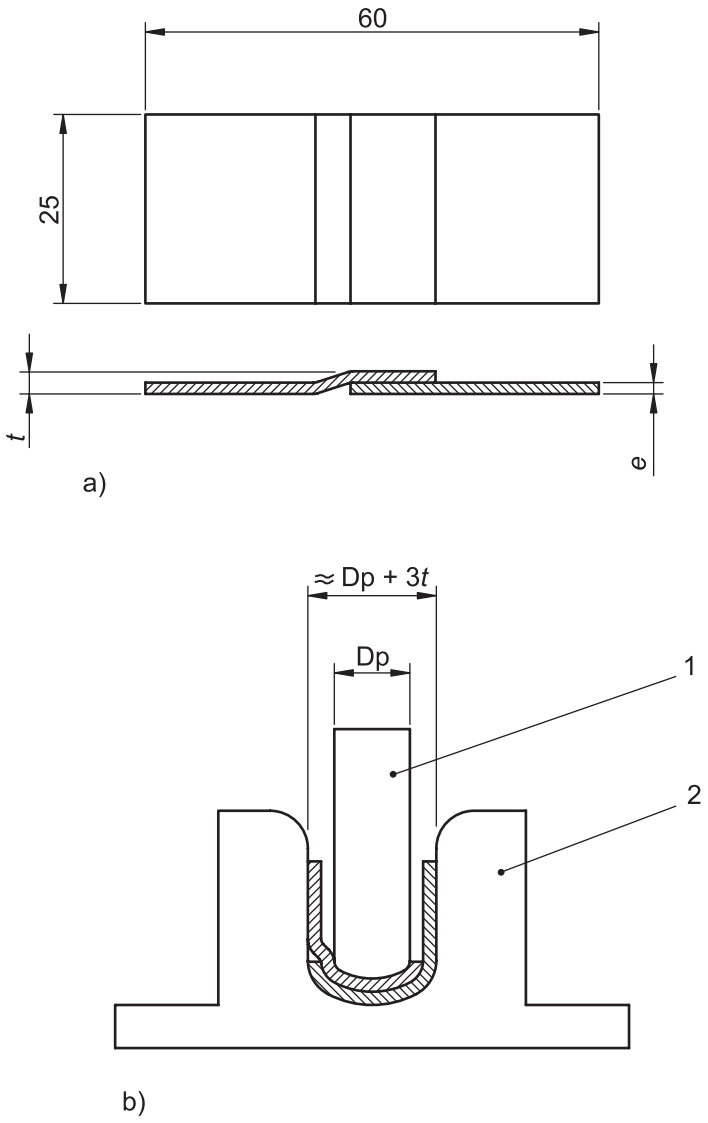
Table 5 — Ratio of mandrel width and test piece thickness

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

7.5.2 Requirements

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

Dimensions in millimetres



Key

a) Dimensions of test specimen
b) Illustration of bend test

1 Mandrel
2 Base

Figure 7 — Bend tests

7.6 Burst test under hydraulic pressure

7.6.1 Procedure

7.6.1.1 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.

7.6.1.2 The burst test under hydraulic 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 fluid used,

— records the pressure at which the cylinder bursts.

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

— the volume of test fluid 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.

7.6.1.4 After the cylinder has burst the rupture surface shall be subject to examination of the tear and the shape of its edges (see 7.6.2.3).

7.6.2 Requirements

7.6.2.1 Bursting pressure

The measured bursting pressure P_b shall not be less than 2,25 times the calculation pressure P_c and at least 35 bar.

7.6.2.2 Volumetric expansion

The ratio of the volumetric expansion of the cylinder to its initial volume shall be greater than or equal to the following values.

For $R_g < 480$ N/mm^2

— 20 % if the length of the cylinder is greater than the diameter, *D*.

— 17 % if the length of the cylinder is equal to or less than the diameter, *D*.

For $R_g \geq 480$ N/mm^2

— 17 % if the length of the cylinder is greater than the diameter, *D*.

— 15 % if the length of the cylinder is equal to or less than the diameter, *D*.

NOTE Length of the cylinder is the length of the pressure envelope including the valve boss.

7.6.2.3 Type of fracture

The examination of the fracture shall show that:

— the fracture did not initiate in a joint,

— the main fracture does not indicate 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 does not reveal a visible defect in the metal, e.g. lamination,

— the burst test does not cause any fragmentation of the cylinder.

7.7 Pressure test

7.7.1 Procedure

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

NOTE ADR [5] and RID [6] require that the use of a gas for the pressure test is agreed with the competent authority.

7.7.1.2 The minimum test pressure (P_h) to be applied shall be the calculation pressure specified in 5.1.3.

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

7.7.1.4 The cylinder shall remain under pressure long enough to establish that no leaks can be observed, but not less than 30 s.

7.7.2 Requirements

7.7.2.1 There shall be no leaks from the cylinder.

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

7.8 Ultrasonic examination

7.8.1 Procedure

Ultrasonic examination of joints shall be carried out in accordance with EN 12799:2000.

The extent of ultrasonic examination shall be 100 % of the circumferential joints as specified in 9.2.

7.8.2 Assessment

Assessment of the ultrasonic test results shall be based on Clause 6 and Figures A1 to A7 of EN 12799:2000.

7.8.3 Requirements

The following imperfections as defined in EN 12799:2000 are not permitted:

— imperfections exceeding 0,5 mm in size;

— any gas pore measuring more than 0,25 x the transverse joint overlap;

— the distance between two gas pores is less than the diameter of the larger of the two pores;

— the effective solid brazing width (i.e. total width of the joint less the width of any imperfections) is less than four times the metal thickness *t*.

7.9 Macro examination

7.9.1 Procedure

The macro examination shall be carried out in accordance with EN 12797.

7.9.2 Requirements

Full transverse sections of the joint shall show complete penetration of the filler metal as illustrated in Figure 4.

The brazing material shall fill the joint and be evenly distributed.

In case of doubt a microscopic examination shall be made of the suspect area.

7.10 Visual examination of the surface of the joint

7.10.1 Procedure

The joint shall be examined in accordance with EN 12799:2000, Clause 5 after the joint has been completed. The brazed surface to be examined shall be well illuminated, and shall be free from grease, dust, scale residue or protective coating of any kind.

7.10.2 Requirements

The joints shall be smooth and free from visible imperfections. Evidence of the brazing material shall be visible around the complete circumference. If this is not the case, additional methods of examination shall be used to prove the integrity of the joint, e.g. ultrasonic testing.

7.11 Fatigue test

7.11.1 Procedure

7.11.1.1 The cylinders shall be filled with a non-corrosive liquid, e.g. water with a corrosion inhibitor, and subjected to successive applications of hydraulic pressure.

7.11.1.2 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.

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

7.11.1.4 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.

7.11.2 Requirement

There shall be no leakage from the cylinder.

8 Technical requirements for type approval

8.1 Extent of testing

The manufacturer shall make available a batch of at least 50 cylinders of each type, which shall be guaranteed as being representative of the production cylinders. The material shall be of the same specification and have the same nominal thickness and the same manufacturing processes as the production cylinders.

Cylinders shall be selected for test as follows:

a) 3 cylinders for a fatigue test in accordance with 7.11 when so required by 5.4, 5.6.2 or Clause 10,

b) 2 cylinders for mechanical tests in accordance with 7.4 and 7.5 and ultrasonic/macro tests in accordance with 7.8 and 7.9,

c) 2 cylinders for a burst test in accordance with 7.6,

d) 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 6.4,

— visual examination of the surface of the joints, in accordance with 7.10.

NOTE These can be the same cylinders used for the mechanical tests.

8.2 Cylinder types

Different designs of cylinder shall be considered to be of the same type within the following limitations:

a) two piece cylinders which have the same:

— nominal diameter,

— nominal length of the pressure envelope, excluding the valve boss,

— nominal end profile,

— minimum thickness,

— material specifications,

and which are:

— equipped with the same openings (see 5.6.2),

— manufactured using the same manufacturing techniques,

— subject to the same heat treatment conditions,

— manufactured using the same type of brazing furnace,

b) three piece cylinders complying with the limitations of 8.2 a) except they can differ in length within the following limits:

— the length of the pressure envelope is not less than 3 *D*,

— the length of the pressure envelope is not more than 1,5 times that of the cylinders type tested.

8.3 Type approval certificate

Each type of cylinder shall be covered by a type approval certificate.

9 Production testing and examination requirements

9.1 Tests and examinations applicable to all cylinders

9.1.1 All finished cylinders, prior to coating, shall be subject to the following:

— a pressure test as specified in 7.7;

— a visual examination of the surface of the joints as specified in 7.10;

— an inspection of the markings as specified in Clause 10.

9.1.2 Cylinders that do not pass the tests shall be rejected and segregated for repair and reassessment or scrapping.

9.2 Ultrasonic examination

9.2.1 Ultrasonic examination shall be carried out on the circumferential joints 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 brazing procedure (including furnace setting), or

— after a break in production exceeding 4 h.

9.2.2 In the case of cylinders with an outside diameter less than 250 mm ultrasonic examination of circumferential joints may be replaced by two macro examinations (see 7.9), one from each side of the cylinder.

9.2.3 Where more than one brazing furnace is used for production, the above procedures shall apply to each furnace.

9.3 Macro examination

9.3.1 Macro examination shall be carried out on the circumferential joints of sample cylinders as detailed in Table 4. The sample cylinders shall be selected in accordance with 9.7.

9.3.2 Macro examination shall be carried out as specified in 7.9.

9.4 Examination of the valve boss joint

Macro examination shall be carried out at sampling rates and on samples taken from cylinders selected for the mechanical/burst tests as specified in 9.7.

9.5 Examination of non-pressure containing joints

Macro examinations shall be carried out on one cylinder out of every thousand cylinders produced.

The examination may be carried out on samples taken from cylinders selected for the mechanical/burst tests specified in 9.7.

NOTE The macro examination may be supplemented by ultrasonic examination at the manufacturer's discretion.

9.6 Unacceptable imperfections found by the ultrasonic or macro examinations

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

9.6.2 Every cylinder brazed since the preceding acceptable ultrasonic or macro examination shall be set aside until it is demonstrated that these cylinders are satisfactory either by ultrasonic 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 procedure as specified in 9.2 has been repeated.

9.6.4 Cylinders that do not pass the tests shall be rejected and segregated for repair and reassessment or scrapping.

9.7 Batch testing (Mechanical / Burst tests)

9.7.1 Batch

A batch shall consist of finished 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 brazing furnaces and subject to the same heat treatment conditions.

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

9.7.2 Inspection lots

For acceptance purposes the 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 batch and sub-lots of 1 000 cylinders, thereafter (see Figure 8).

9.7.3 Rate of sampling

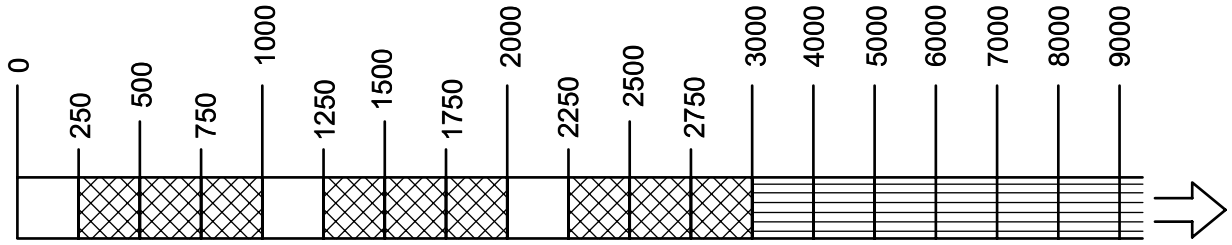
9.7.3.1 General

Where a 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 batch production test results and manufacturing processes are consistently reliable without any major interruption of manufacture.

Except as permitted by 9.7.3.4, the samples taken for "**B**urst tests **or M**echanical tests" shall be alternated between the mechanical and the burst tests.

A chart illustrating the rate of sampling is given in Figure 8.



Size of lot/sub-lot	Symbol	No. of cylinders	Type of tests
250		2	one subjected to the **B**urst test **and** one subjected to the **M**echanical test.
250		1	one subjected to the **B**urst test **or** the **M**echanical test.
500		2	one subjected to the **B**urst test if one has been subjected to the **M**echanical test in the previous sub-lot/lot and vice versa.
500		1	one subjected to the **B**urst test if one has been subjected to the **M**echanical test in the previous sub-lot/lot and vice versa.
1 000		2	one subjected to the **B**urst test **and** one subjected to the **M**echanical test.

NOTE Cylinders required by 9.7.2 to be subject to mechanical tests and which have a water capacity less than 6,5 l and a burst pressure greater than 100 bar can, at the manufacturer's discretion, be subjected to the alternative burst test.

Figure 8 — Inspection lots

9.7.3.2 Batch less than or equal to 3 000 cylinders

9.7.3.2.1 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.

9.7.3.2.2 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.

9.7.3.3 Batch over 3 000 cylinders

For the first 3 000 cylinders in the batch, representative cylinders shall be taken as specified in 9.7.3.2. For the remaining cylinders, from each inspection lot (1 000 cylinders), representative cylinders shall be taken at random, one for the burst test and one for mechanical tests.

9.7.3.4 Cylinder 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.

9.7.4 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,

— tolerance checks to confirm compliance with the requirements of 6.4.

9.8 Failure to meet mechanical and burst test requirements

9.8.1 Mechanical

9.8.1.1 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.

9.8.1.2 If the second test confirms the initial test result, the procedure specified in 9.8.3.1 or 9.8.3.2 shall be followed.

9.8.2 Burst

In the event of a single cylinder failing the burst test, the procedure specified in 9.8.3.1 or 9.8.3.2 shall be followed.

9.8.3 Re-test

9.8.3.1 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 6, the retest cylinders shall be taken at random from the same inspection lot/sub-lot.

Table 6 — Re-test requirements

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

In the event that there is no failure from the retest the inspection lot shall be accepted.

9.8.3.2 In the event of more than one cylinder failing the tests or one or more cylinders failing the retest specified in 9.8.3.1 the inspection lot shall be rejected.

9.8.4 Resubmission of an inspection lot

The manufacturer may;

— re heat-treat the rejected inspection lot, or

— repair any joint defects by adding brazing paste locally and then re-brazing by heating the whole cylinder,

and then resubmit the inspection lot as a new inspection lot as specified in 9.7.

10 Marking

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

NOTE 1 The requirements of EN 14894:2006 comply with RID/ADR 2009.

NOTE 2 EN 14894 will be regularly amended/revised to ensure its requirements comply with the latest version of RID/ADR.

Where the marking is directly on the pressure envelope, it shall be demonstrated by the fatigue and burst tests that failure does not initiate in the markings and the markings remain legible.

11 Certificates

In addition to the type approval certificate required in 8.3, each batch of cylinders shall be covered by a certificate stating that the cylinders comply with the approved type and meet the requirements of this European Standard in all respects.

NOTE ADR [5] and RID [6] include detailed requirements on the elements to be shown on type approval and compliance certificates.

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[6] RID, Regulations concerning the International Carriage of Dangerous Goods by Rail

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