

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

The European Standard EN 1975:1999, with the incorporation of amendment A1:2003, has the status of a British Standard

ICS 23.020.30

National foreword

This British Standard is the official English language version of EN 1975:1999, including amendment A1:2003. It partially supersedes BS 5045-3:1984, which will be amended accordingly and be renumbered as BS 5045-8 to cover special portable applications.

The UK participation in its preparation was entrusted by Technical Committee PVE/3, Gas containers, to Subcommittee PVE/3/3, Transportable gas containers — Cylinder design and construction and testing a time of manufacture, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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English version

**Transportable gas cylinders – Specification for the design and construction of refillable transportable seamless aluminium and aluminium alloy gas cylinders of capacity from 0,5 litre up to 150 litre
(includes amendment A1:2003)**

Bouteilles à gaz transportables - Spécifications pour la conception et la fabrication de bouteilles à gaz rechargeables et transportables en aluminium et alliage d'aluminium sans soudure de capacité comprise entre 0,5 l et 150 l inclus
(inclut l'amendement A1:2003)

Ortsbewegliche Gasflaschen - Gestaltung und Konstruktion von wiederbefüllbaren ortsbeweglichen nahtlosen Gasflaschen aus Aluminium und Aluminiumlegierung mit einem Fassungsraum von 0,5 l bis einschließlich 150 l
(enthält Änderung A1:2003)

This European Standard was approved by CEN on 20 December 1998. Amendment A1 was approved by CEN on 3 November 2003.

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

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 023, “Transportable gas cylinders”, the secretariat of which is held by BSI.

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

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 1999, and conflicting national standards shall be withdrawn at the latest by August 1999.

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

Foreword to amendment A1

This document (EN 1975:1999/A1 :2003) has been prepared by Technical Committee CEN/TC 23 “Transportable gas cylinders” the secretariat of which is held by BSI.

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

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

This amendment to the European Standard EN 1975:1999 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

This amendment has been prepared to replace the existing Annex G by a normative annex covering specific requirements for aluminium alloy 2001.

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

Introduction

The purpose of this standard is to provide a specification for the design, manufacture, inspection and approval of refillable transportable seamless aluminium and aluminium alloy gas cylinders. The specifications given are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and control during manufacture, of cylinders in common use in the countries of the CEN members.

1 Scope

This standard specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of refillable transportable seamless aluminium and aluminium alloy gas cylinders of water capacities from 0,5 l up to and including 150 l for compressed, liquefied and dissolved gases.

2 Normative references

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

EN 962:1996, *Transportable gas cylinders — Valve protection caps and valve guards for industrial and medical gas cylinders — Design, construction and tests*.

EN 1089-1:1996, *Transportable gas cylinders — Gas cylinder identification — Part 1: Stampmarking*.

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test*.

EN 10003-1, *Metallic materials — Brinell hardness test — Part 1: Test method*.

EN ISO 13341, *Transportable gas cylinders — Fitting of valves to gas cylinders*.

EURONORM 6-55, *Bend test for steel*.

EURONORM 12-55, *Bend test of sheet steels and strips with a thickness of less than 3 mm*.

EN ISO 7539-6:1995, *Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens* (ISO 7539-6:1989).

3 Definitions and symbols

For the purposes of this standard the following definitions and symbols apply.

3.1 Definitions

3.1.1

yield stress

value corresponding to 0,2 % proof stress (non-proportional elongation), $R_{p0,2}$ for aluminium alloys, or 1 % proof stress for unalloyed aluminium in the unhardened state

3.1.2

solution heat treatment

thermal treatment which consists of heating the products to a suitable temperature, holding at that temperature long enough to allow constituents to enter into solid solution and cooling rapidly enough to hold the constituents in solution

3.1.3

quenching

controlled rapid cooling in a suitable medium to retain the solute phase in solid solution

3.1.4

artificial ageing

heat treatment process in which the solute phase is precipitated to give an increased yield stress and tensile strength

3.1.5

stabilizing heat treatment

heat treatment applied to some 5000 series aluminium alloys in order to prevent changes in mechanical properties and structure under service conditions

3.1.6

batch

quantity of up to 200 cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design, made successively from the same cast and subjected to the same heat treatment for the same duration of time

3.1.7

mass

mass of a cylinder, expressed in kilogrammes, comprising the combined mass of cylinder and permanently attached parts (e.g. foot ring, neck ring, etc.) but without valve

3.1.8

design stress factor (F) (variable)

ratio of equivalent wall stress at test pressure (p_h) to guaranteed minimum yield stress (R_e)

3.2 Symbols

a	Calculated minimum thickness, in millimetres, of the cylindrical shell
a'	Guaranteed minimum thickness, in millimetres, of the cylindrical shell
A	Percentage elongation, determined by the tensile test 7.1.2.1
b	Guaranteed minimum thickness, in millimetres, at the centre of a convex base (see Figure 1)
d	Diameter of former, in millimetres (see Figure 5)
D	Nominal outside diameter of the cylinder, in millimetres (see Figure 1)
F	Design stress factor (variable) (see 3.1.8)
H	Outside height of domed part (convex head or base end), in millimetres (see Figure 1)
n	The ratio of the diameter of the bend test former to actual thickness of test piece (t)
p_b	Measured burst pressure, in bar ¹⁾ above atmospheric pressure
p_{lc}	Lower cyclic pressure, in bar ¹⁾ above atmospheric pressure
p_h	Hydraulic test pressure, in bar ¹⁾ above atmospheric pressure
p_y	Observed yield pressure, in bar ¹⁾ above atmospheric pressure
r	Inside knuckle radius, in millimetres (see Figure 1)
r_i	Inside crown radius, in millimetres (see Figure 1)
R_e	Minimum guaranteed value of yield stress (see 3.1.1), in megapascals, for the finished cylinder
R_{ea}	Actual value of yield stress, in megapascals, determined by the tensile test 7.1.2.1
R_g	Minimum guaranteed value of tensile strength, in megapascals, for the finished cylinder
R_m	Actual value of tensile strength, in megapascals, determined by the tensile test 7.1.2.1
S_o	Original cross-sectional area of tensile test piece, in square millimetres, according to EN 10002-1
t	Actual thickness of test specimen, in millimetres

¹⁾ 1 bar = 10⁵ Pa = 0,1 MPa.

4 Materials

4.1 General provisions

4.1.1 Gas cylinders may be manufactured from unalloyed aluminium of at least 99,5 % purity.

4.1.2 Aluminium alloy(s) may be used to produce gas cylinders provided that they satisfy the requirements of the corrosion resistance tests defined in Annex A, meet all other requirements of this standard including Annex B, and are approved by the relevant Authority.

The alloys most commonly used for the fabrication of gas cylinders are those given in Table 1.

4.1.3 The cylinder manufacturer shall identify the cylinders with the particular casts of the alloy from which they are made, and shall obtain and provide certificates of the analyses of the casts used.

4.2 Heat treatment

4.2.1 *Heat treatable alloys*

The manufacturer shall specify on the prototype testing documentation the solution heat treatment and artificial ageing temperatures and the times for which the cylinders have been held at those temperatures. The medium used for quenching after solution heat treatment shall be identified.

4.2.2 *Non-heat treatable alloys*

The manufacturer shall specify on the prototype testing documentation the type of metal forming operation carried out (extrusion, drawing, ironing, head forming, etc.).

Unless the alloy is subjected to a temperature in excess of 400 °C during the forming process, a stabilizing heat treatment shall be carried out and the temperature and time at temperature shall be identified by the manufacturer.

4.2.3 Control of specified heat treatment

During the heat treatment, the manufacturer shall comply with the specified temperatures and durations, within the following tolerances:

a) Temperatures

Solution temperature	$\pm 10\text{ }^{\circ}\text{C}$
Artificial ageing temperature	$\pm 5\text{ }^{\circ}\text{C}$
Stabilizing temperature	$\pm 10\text{ }^{\circ}\text{C}$

b) Durations

Time cylinders actually spend at temperature during treatments:

Solution treatment	$\pm 30\%$
Ageing treatment	$\pm 20\%$
Stabilizing treatment	$\pm 10\%$

Table 1 — Chemical composition of aluminium alloys

Type of alloy AA ¹⁾ registered designation	Marking code reference		Chemical composition weight %													
			Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Zr	Pb	Others Each	Total	Aluminium
5283A	5283	min	—	—	—	0,50	4,5	—	—	—	—	—	—	—	—	Remainder
		max	0,30	0,30	0,03	1,0	5,1	0,05	0,03	0,10	0,03	0,05	0,0030	0,05	0,15	Remainder
6061A	6061	min	0,40	—	0,15	—	0,8	0,04	—	—	—	—	—	—	—	Remainder
		max	0,80	0,7	0,40	0,15	1,2	0,35	—	0,25	0,15	—	0,0030	0,05	0,15	Remainder
6082A	6082	min	0,7	—	—	0,40	0,60	—	—	—	—	—	—	—	—	Remainder
		max	1,3	0,50	0,10	1,0	1,2	0,25	—	0,20	0,10	—	0,0030	0,05	0,15	Remainder
6351A	6351	min	0,7	—	—	0,40	0,40	—	—	—	—	—	—	—	—	Remainder
		max	1,3	0,50	0,10	0,8	0,8	—	—	0,20	0,20	—	0,0030	0,05	0,15	Remainder
7060	7060	min	—	—	1,8	—	1,3	0,15	—	6,1	—	—	—	—	—	Remainder
		max	0,15	0,20	2,6	0,20	2,1	0,25	—	7,5	0,05	0,05	0,0030	0,05	0,15	Remainder

¹⁾ AA is the Aluminum Association Inc., 900 19th Street N.W., Washington D.C., 20006-2168, USA.

NOTE Where a melt contains scrap or other re-used material the bismuth content shall not exceed 0,0030 %.

5 Design

5.1 General provisions

5.1.1 The calculation of the wall thickness of the pressure-containing parts shall be related to the yield stress (R_e) of the material to ensure elastic behaviour.

5.1.2 For calculation purposes the value of the yield stress (R_e) is limited to a maximum of $0,90 R_g$ for aluminium alloys.

5.1.3 The internal pressure upon which the calculation of wall thickness is based shall be the hydraulic test pressure (p_h).

5.1.4 For dissolved acetylene, the manufacturing process of the porous mass can modify the characteristics of the aluminium alloy used. This shall be considered when designing the shell.

5.2 Calculation of cylindrical wall thickness

The guaranteed minimum thickness of the cylindrical shell (a') shall not be less than the thickness calculated using the equation:

$$a = \frac{D}{2} \left(1 - \sqrt{\frac{10 F R_e - \sqrt{3} P_h}{10 F R_e}} \right)$$

where the value of F is the lesser of $\frac{0,65}{(R_e / R_g)}$ or $0,77$.

R_e/R_g shall be limited to $0,90$.

The calculated minimum thickness shall also satisfy the equation:

$$a \geq \frac{D}{100} + 1 \text{ mm}$$

with an absolute minimum of $a = 1,5 \text{ mm}$.

When choosing the minimum guaranteed value of the thickness of the cylindrical shell (a'), the manufacturer shall take into account all requirements for prototype and production testing, particularly the burst and yield pressure test requirements of **7.2.2.2**.

For examples of wall thickness calculations, see Annex E.

5.3 Design of ends (heads and bases)

The thickness and shape of the base and head of the cylinders shall be such as to meet the requirements of the tests laid down in 7.2 and 7.3.

In order to achieve satisfactory stress distribution, the cylinder wall thickness shall increase progressively in the transition zone between the cylindrical shell and the ends, particularly the base. For example, typical shapes of convex heads and base ends are shown in Figure 1. The thickness at any part of the base shall not be less than the guaranteed minimum thickness of the cylindrical part.

The inside knuckle radius (r) shall not be less than 10 % of the inside diameter of the shell.

For convex ends, the inside crown radius (r_i) shall not be greater than $1,2 \times$ the inside diameter of the shell.

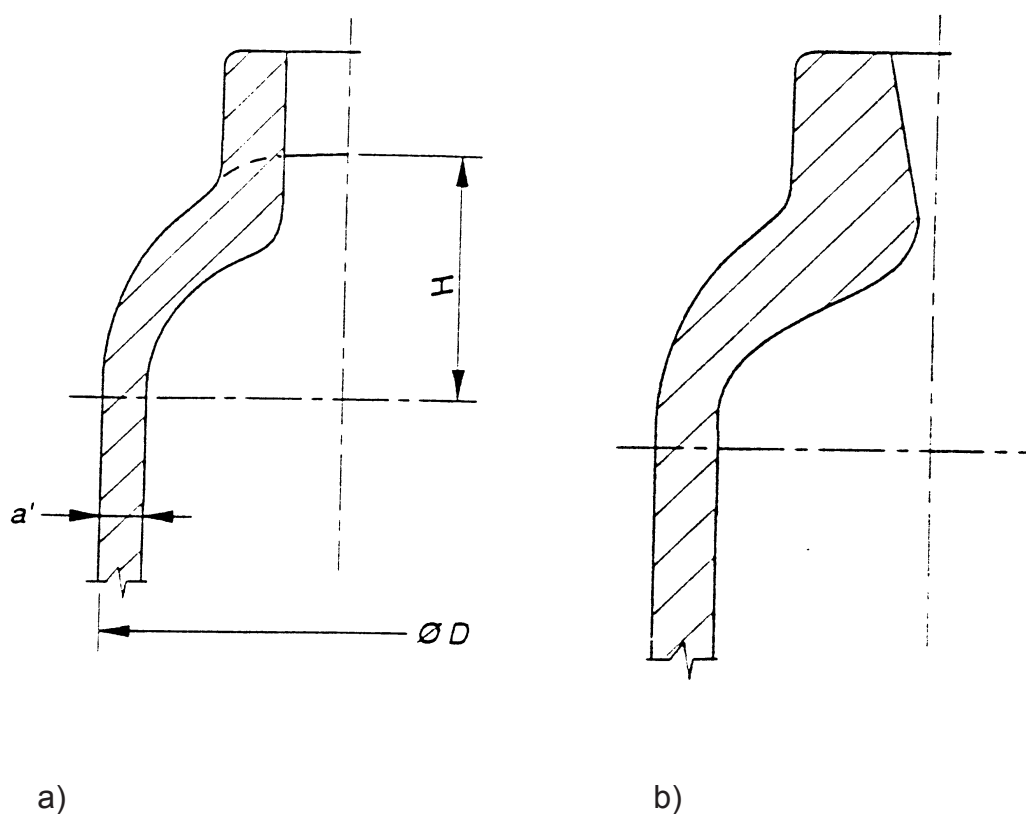


Figure 1 — Examples of convex ends (*continued*)

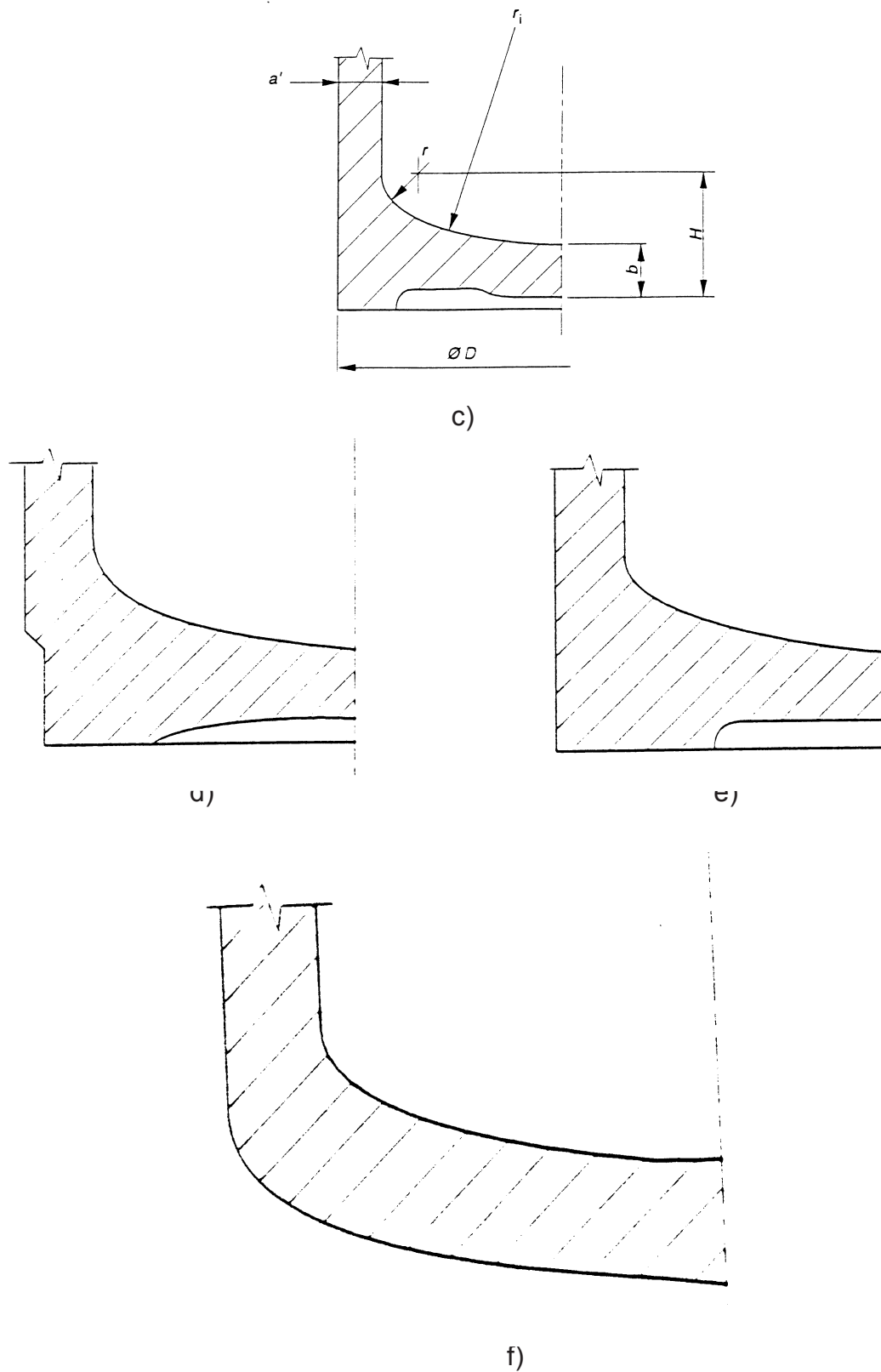
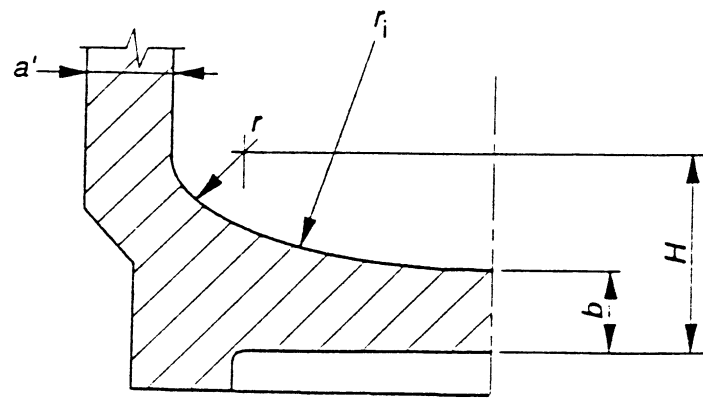
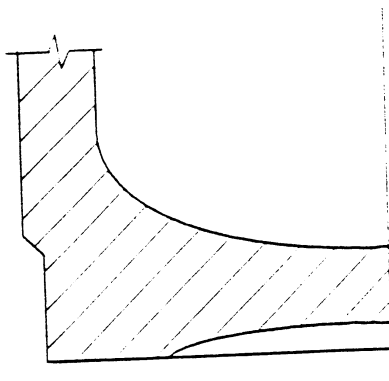


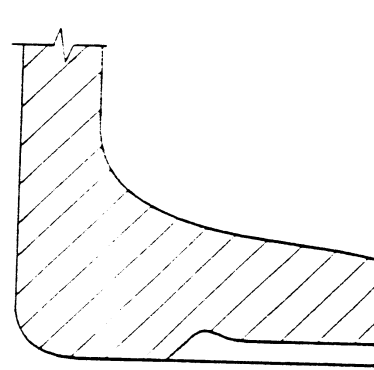
Figure 1 — Examples of convex ends (*continued*)



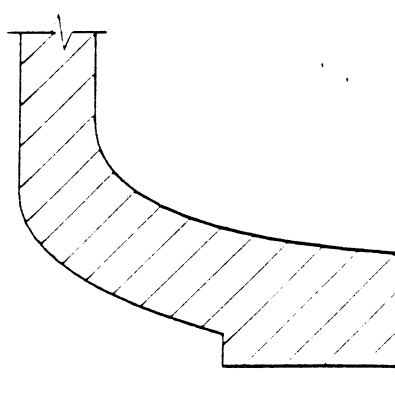
g)



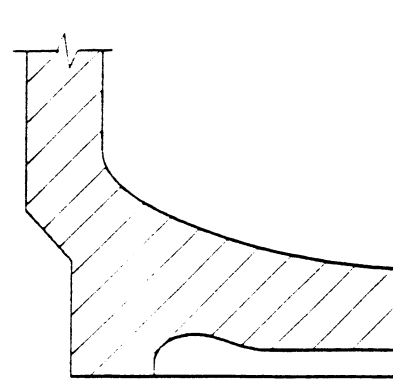
h)



i)



j)



k)

Figure 1 — Examples of convex ends (continued)

5.4 Neck design

5.4.1 The external diameter and thickness of the formed neck end of the cylinder shall be adequate for the torque applied in fitting the valve to the cylinder. The torque may vary according to the diameter of thread, the form, and the sealant used in the fitting of the valve. The torques specified in EN ISO 13341 shall not be exceeded, since this could result in permanent damage to the cylinder. Where the cylinder manufacturer specifies a lower torque this also shall not be exceeded. The manufacturer shall notify any such requirements to the purchaser of aluminium or aluminium alloy cylinders.

5.4.2 The thickness of the wall in the cylinder neck shall be sufficient to prevent permanent expansion of the neck during initial and subsequent fitting of the valve into the cylinder. Where the cylinder is specifically designed to be fitted with neck reinforcement, such as a neck ring or shrunk-on collar, this may be taken into account (see EN ISO 13341).

5.4.3 Cylinders may be designed with one or two openings along the central cylinder axis only.

5.5 Foot-rings

As agreed between the parties, a foot-ring, if provided, shall be sufficiently strong and made of material compatible with that of the cylinder. In addition, the shape should preferably be cylindrical and shall give the cylinder sufficient stability. The foot-ring shall be secured to the cylinder by a method other than welding, brazing or soldering. Any gaps which may form water traps shall be sealed to prevent ingress of water, by a method other than welding, brazing or soldering.

5.6 Neck-rings

When a neck ring is provided, it shall be of material compatible with that of the cylinder, and shall be securely attached by a method other than welding, brazing or soldering.

The manufacturer shall ensure that the axial load required to remove the neck ring is greater than 10 times the weight of the empty cylinder and not less than 1000 N, also that the minimum torque required to turn the neck ring is greater than 100 N·m.

The valve protection requirements shall be as specified in EN 962.

5.7 Design drawing

A fully dimensioned drawing shall be supplied which includes the specification of the material and makes reference to this standard.

6 Construction and workmanship

6.1 General

The cylinder shall be produced by:

- a) cold or hot extrusion from cast or extruded or rolled billet;
- b) cold or hot extrusion, followed by cold drawing, from cast or extruded or rolled billet;
- c) cupping, flow forming, spinning and cold drawing sheet or plate;
- d) open necking at both ends of an extruded or cold drawn tube (see Figure 2).

6.2 Welding

Welding of seamless aluminium and aluminium alloy gas cylinders is not permitted under any circumstances.

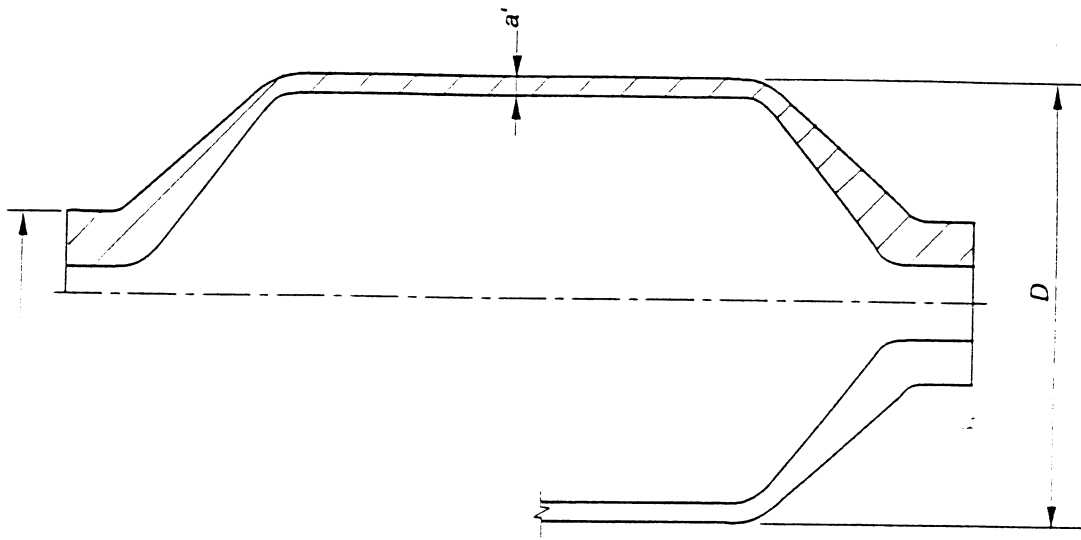


Figure 2 — Necked ends from tube

6.3 Wall thickness

Each cylinder shall be examined for thickness and for external and internal surface defects. The wall thickness at any point shall not be less than the minimum thickness specified.

6.4 End forming

The ends shall be formed by an appropriate method, e.g. forging, swaging and spinning. Prior to and/or after the closing-in operation, all significant remnants of the as-cast structure of the open end of the shell shall be removed.

Where heat has to be applied in order to form the cylinder neck/shoulder, uniform heat distribution shall be achieved prior to the forming operation (e.g. by means of induction heating). This heat distribution shall be achieved independent of the process employed for the manufacture of the shell.

For 6000 series alloys special precautions shall be taken to achieve a fine grain structure in the neck of the finished cylinder.

Regardless of the method used for the closing-in operation, the tools used for the head forming process shall facilitate metal flow and result in smooth surfaces of the cylinder especially in the neck/shoulder areas. There shall be no sudden contour changes or significant folds, (see **6.7**) which can act as stress raisers during the cylinder's eventual service conditions.

6.5 Surface defects

The internal and external surfaces of the finished cylinder shall be free from defects, which would adversely affect the safe working of the cylinder. Such defects shall be removed by local dressing. The wall thickness of any dressed area shall not be less than the minimum thickness specified.

6.6 Neck threads

The internal neck threads shall conform to a recognized standard agreed between the parties to permit the use of a corresponding valve thus minimizing neck stresses following the valve torquing operation. Internal neck threads shall be checked using gauges corresponding to the agreed neck thread, or by an alternative method agreed between the parties.

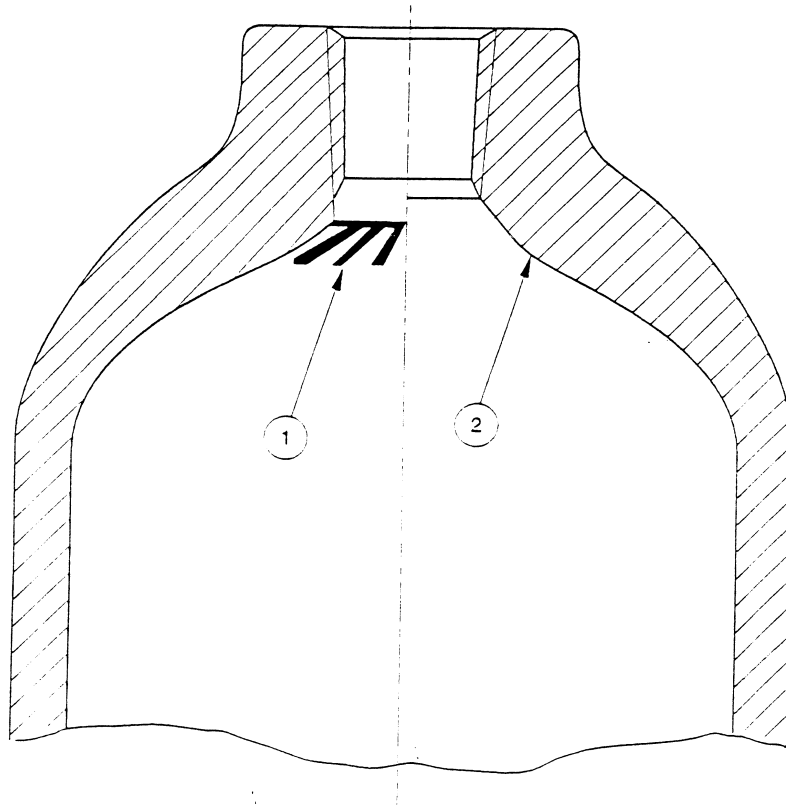
For example, where the neck thread is specified to be in accordance with EN 629-1, the corresponding gauges are specified in EN 629-2.

Particular care shall be taken to ensure that neck threads are accurately cut, are of full form and free from any sharp profiles, e.g. burrs.

6.7 Examination for surface imperfections and neck folds

Each cylinder shall be examined for neck folds by a suitable means (e.g. introscope, borescope, dental mirror, tactile, ultrasonics). Folds that are visible as a line running into the threaded portion, as shown on the left hand side of Figure 3, shall be removed by a machining operation until the lines are no longer visible.

After the machining operation the thickness of the machined area and the thread characteristics shall be at least that required to pass all necessary testing. The whole internal shoulder area shall be re-inspected to verify that folding or its lines have been removed.



Key

- 1 Folds
- 2 Machine away

Figure 3 — Example of cylinder neck folds before and after machining

6.8 Out of roundness

The out-of-roundness of the cylindrical shell, i.e. the difference between the maximum and minimum outside diameters at the same cross-section, shall not exceed 2 % of the mean of these diameters.

6.9 Straightness

The maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 3 mm per metre length.

6.10 Stability

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

6.11 Mean diameter

The mean external diameter shall not deviate more than ± 1 % from the nominal design diameter.

7 Tests

7.1 Mechanical tests

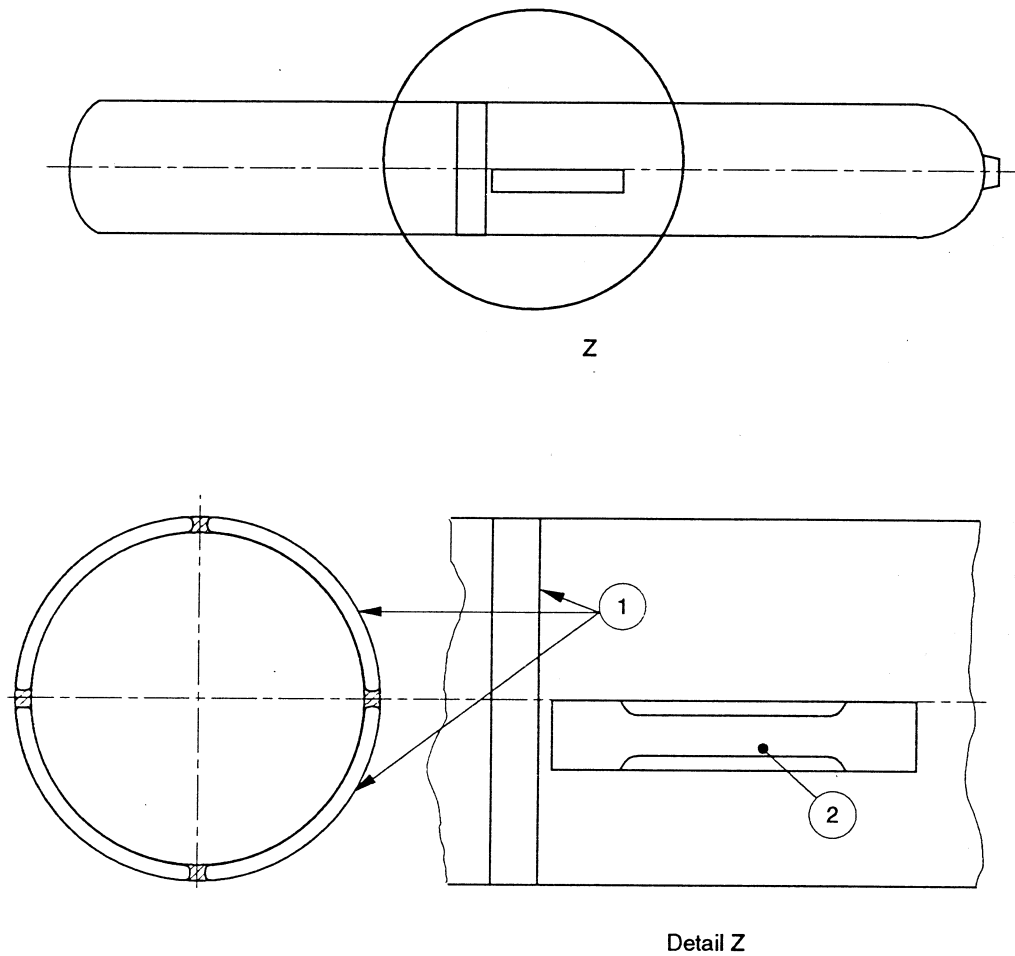
7.1.1 General requirements

All mechanical tests for checking the quality of the metal used for gas cylinders shall be carried out on material taken from cylinders on which all operations affecting mechanical properties have been completed. They do not need to have been pressure tested.

Except for the requirements set out below, the mechanical tests shall be carried out in accordance with EN 10002-1, EN 10003-1, EURONORM 6-55 and EURONORM 12-55.

7.1.2 Types of test and evaluation of test results

On every test cylinder there shall be carried out one tensile test in a longitudinal direction and four bend tests in a circumferential direction. For location of test pieces, see Figure 4.



Key

- 1 Bend test pieces
- 2 Tensile test pieces

Figure 4 — Location of test pieces

7.1.2.1 *Tensile test*

7.1.2.1.1 The test piece on which the tensile test is carried out shall conform to the provisions of EN 10002-1 with a gauge length of $5,65 \sqrt{S_0}$.

The two faces of the test-piece corresponding to the internal and external walls of the cylinder shall not be machined.

7.1.2.1.2 With regard to the heat treatable alloys referred to in Table 1, and the alloys referred to in **4.1.2**, elongation after fracture (A) shall not be less than 12 %.

With regard to the non-heat treatable alloys referred to in Table 1, the elongation after fracture shall not be less than 12 %, where the tensile test is carried out on a single test piece taken from the cylinder wall. The tensile test may also be carried out on four test pieces distributed uniformly throughout the cylinder wall. The results shall be as follows:

- no individual value may be less than 11 %.
- the average of the four measurements shall be at least 12 %.

In the case of unalloyed aluminium, the elongation after fracture shall not be less than 12 %.

7.1.2.1.3 The value obtained for tensile strength shall not be less than R_g . The yield stress (R_{ea}) to be determined during the tensile test shall be that used in accordance with **3.1.1** for the cylinder calculation. The value obtained for the yield stress shall not be less than R_e .

7.1.2.2 *Bend test*

7.1.2.2.1 The bend tests shall be carried out on four test pieces obtained by cutting either one or two rings of width $3a'$ (± 1 mm) into equal parts; in no case shall the width of the test piece be less than 25 mm. Each test piece shall be of sufficient length to permit the bend test to be carried out correctly. Each ring may be machined only on the edges. These edges may be rounded to a radius of no more than $1/10$ of the thickness of the test pieces or chamfered at an angle of 45° and a width of less than $1/10$ of the thickness of the test pieces.

7.1.2.2.2 The bend tests shall be carried out using a former of diameter d and two rollers separated by a distance of $d + 3a'$. During the test, the inside face of the ring shall remain in contact with the former. Several test pieces can be tested at the same time on the same test machine. (See Figure 5).

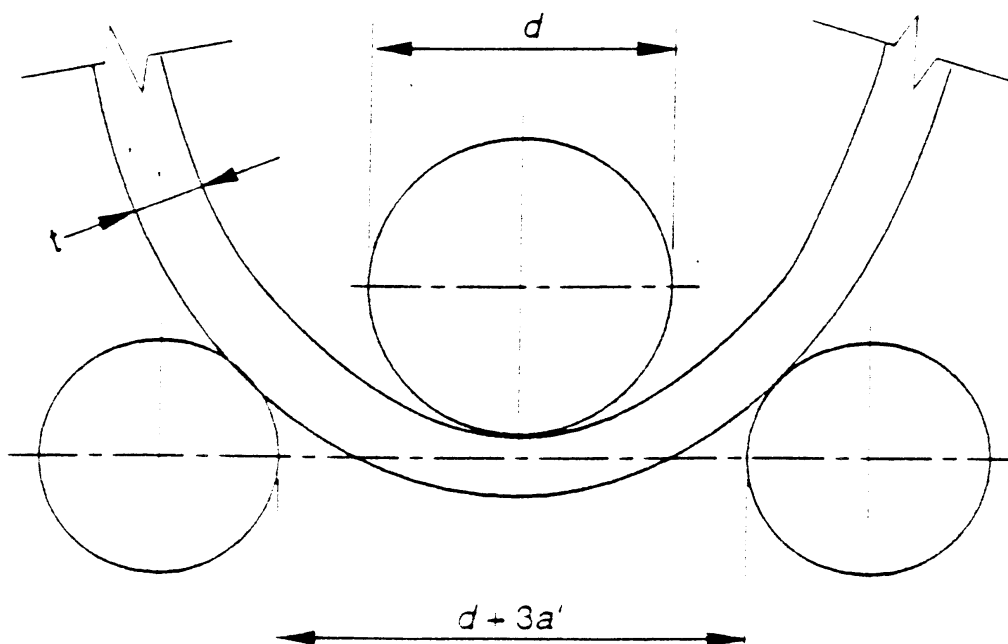


Figure 5 — Illustration of bend test

7.1.2.2.3 The test piece shall not crack when bent inwards around the former until the inside edges are not further apart than the diameter of the former (see figure 5).

7.1.2.2.4 The ratio (n) between the diameter of the former and the thickness of the test piece shall not exceed the values given in the following Table 2.

Table 2 — Bend test requirements

Actual tensile strength R_m MPa	Value of n
$R_m \leq 220$	5
$220 < R_m \leq 330$	6
$330 < R_m \leq 440$	7
$R_m > 440$	8

7.2 Hydraulic burst test

7.2.1 Test conditions

7.2.1.1 Cylinders subjected to this test shall bear markings in accordance with EN 1089-1.

7.2.1.2 The hydraulic burst test shall be carried out using a test-rig which allows pressure to be increased at a controlled rate until the cylinder bursts and the curve of pressure variation versus volumetric expansion or time to be produced. The test shall be carried out at room temperature (the temperature of the cylinder shall be less than 40 °C). (See Figure 6.)

7.2.1.3 During the first stage (elastic deformation), the rate of increase in pressure shall be approximately constant up to the level at which plastic deformation starts. In the second stage, the pump discharge rate shall be maintained as constant as possible until the cylinder bursts.

The duration of the test shall not be less than 2 min.