COUNCIL DIRECTIVE

of 17 September 1984

on the approximation of the laws of the Member States relating to seamless, unalloyed aluminium and aluminium alloy gas cylinders

(84/526/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 100 thereof,

Having regard to the proposal from the Commission (1),

Having regard to the opinion of the European Parliament (2),

Having regard to the opinion of the Economic and Social Committee (3),

Whereas in the Member States the construction and inspection of gas cylinders are subject to mandatory provisions which differ from one Member State to another and consequently hinder trade in such cylinders; whereas it is therefore necessary to approximate these provisions;

Whereas Council Directive 76/767/EEC of 27 July 1976 on the approximation of the laws of the Member States relating to common provisions for pressure vessels and methods of inspecting them (4), as amended by the Act of Accession of 1979, lays down in particular the EEC pattern approval and verification procedures for these vessels; whereas, in accordance with that Directive, it is necessary to lay down the technical requirements to be complied with by EEC-type seamless, unalloyed aluminium and aluminium alloy gas cylinders with a capacity of 0,5 to 150 litres in order to be imported, marketed and used without restraint after undergoing the inspections and having affixed to them marks and signs laid down,

HAS ADOPTED THIS DIRECTIVE:

Article 1

1. This Directive shall apply to seamless, unalloyed aluminium and aluminium alloy gas cylinders, formed from a single piece, capable of being refilled and transported, with a capacity of between 0,5 and 150 litres inclusive and designed to contain compressed, liquefied or dissolved gases. These gas cylinders are hereinafter referred to as 'cylinders'.

2. This Directive shall not apply to:

— cylinders manufactured from an aluminium alloy with a guaranteed minimum tensile strength greater than 500 N/mm²,

— cylinders to which metal is added when the base is being sealed.

Article 2

For the purpose of this Directive, 'EEC-type cylinder' shall mean any cylinder designed and manufactured in such a way that it satisfies the requirements of this Directive and of Directive 76/767/EEC.

Article 3

No Member State may, on grounds relating to the construction or inspection of a cylinder within the meaning of Directive 76/767/EEC and this Directive, refuse, prohibit or restrict the placing on the market and putting into service of an EEC-type cylinder.

Article 4

All EEC-type cylinders shall be subject to EEC pattern approval.

All EEC-type cylinders shall be subject to EEC verification with the exception of cylinders with a hydraulic test pressure of 120 bars or less and a capacity of not more than one litre.

Article 5

Any amendments necessary to adapt sections 2.1.5, 2.4, 3.1.0, 3.4, 3.5, 3.6, 3.7, 4, 5 and 6 of Annex I and the other Annexes to this Directive to technical progress

(1) OJ No C 104, 13. 9. 1974, p. 75.
(2) OJ No C 5, 8. 1. 1975, p. 52.
(3) OJ No C 62, 15. 3. 1975, p. 32.
(4) OJ No L 262, 27. 9. 1976, p. 153.

shall be adopted in accordance with the procedure laid down in Article 20 of Directive 76/767/EEC.

Article 6

The procedure laid down in Article 17 of Directive 76/767/EEC shall apply to section 2.3 of Annex I to this Directive.

Article 7

1. Member States shall bring into force the laws, regulations and administrative provisions needed in order to comply with this Directive within 18 months following its notification (1) and shall forthwith inform the Commission thereof.

2. Member States shall ensure that the texts of the provisions of national law which they adopt in the field covered by this Directive are communicated to the Commission.

Article 8

This Directive is addressed to the Member States.

Done at Brussels, 17 September 1984.

For the Council

The President

P. BARRY

(1) This Directive was notified to the Member States on 26 September 1984.

ANNEX I

1. TERMS AND SYMBOLS USED IN THIS ANNEX

1.1. YIELD STRESS

For the purposes of this Directive, the yield stress values used in calculations of the pressure parts shall be as follows:

— for aluminium alloys, the 0,2 % proof stress $R_{p\,0,2}$, i.e. the value of the stress which gives rise to a non-proportional elongation equal to 0,2 % of the gauge length of the test-piece,

— for unalloyed aluminium in the unhardened state, the 1 % proof stress.

1.2. For the purposes of this Directive, 'bursting pressure' means the pressure at plastic instability, i.e. the maximum pressure obtained during a pressure bursting test.

1.3. The symbols used in this Annex have the following meanings:

P_h = hydraulic test pressure, in bars;

P_r = cylinder busting pressure measured during the bursting test, in bars;

P_{rt} = calculated minimum theoretical bursting pressure, in bars;

R_e = minimum value of the yield stress guaranteed by the cylinder manufacturer, in N/mm^2;

R_m = minimum value of the tensile strength guaranteed by the cylinder manufacturer, in N/mm^2;

a = calculated minimum thickness of the wall of the cylindrical part of the cylinder, in mm;

D = nominal external diameter of the cylinder, in mm;

R_{mt} = actual tensile strength, in N/mm^2;

d = mandrel diameter for bend tests, in mm.

2. TECHNICAL REQUIREMENTS

2.1. MATERIALS USED, HEAT AND MECHANICAL TREATMENT

2.1.1. An aluminium alloy or unalloyed aluminium shall be defined according to its method of manufacture, its nominal chemical composition and the heat treatment undergone by the cylinder, the latter's resistance to corrosion and its mechanical properties. The manufacturer shall give the corresponding information, taking account of the requirements listed below. Any change in such information shall be deemed to correspond to a change in the type of material for the purposes of EEC pattern approval.

2.1.2. The following are permitted for the manufacture of cylinders:

(a) all unalloyed aluminium containing at least 99,5 % aluminium;

(b) aluminium alloys with the chemical composition set out in table 1 which have undergone the heat and mechanical treatments listed in table 2;

TABLE 1

	Chemical composition in %										
	Cu	Mg	Si	Fe	Mn	Zn	Cr	Ti+Zr	Ti	Total others	Al
Alloy B											
min.	—	4,0	—	—	0,5	—	—	—	—		remain-
max.	0,10	5,1	0,5	0,5	1,0	0,2	0,25	0,20	0,10	0,15	der
Alloy C											
min.	—	0,6	0,7	—	0,4	—	—	—	—		remain-
max.	0,10	1,2	1,3	0,5	1,0	0,2	0,25	—	0,10	0,15	der

TABLE 2

	Heat and mechanical treatments
Alloy B	In order: 1. Blank inhibition treatment: — duration determined by the manufacturer, — temperature between 210 and 260 °C. 2. Extrusion with a degree of cold-working of at most 30 %. 3. Formation of head: the temperature of the metal must be no less than 300 °C at the end of the process.
Alloy C	1. Placing in solution before quenching: — duration determined by the manufacturer, — temperature in no case less than 525 °C or above 550 °C. 2. Quenching 3. Artificial ageing: — duration determined by the manufacturer, — temperature of between 140 and 190 °C.

(c) any other aluminium alloy may be used for the manufacture of cylinders provided that it first passes the corrosion-resistance tests described in Annex II.

2.1.3. The cylinder manufacturer must obtain and provide cast-analysis certificates for the material used for the manufacture of the cylinders.

2.1.4. There must be an opportunity for making independent analyses. These analyses must be carried out either on specimens taken from the semi-finished product as supplied to the cylinder manufacturer or on the finished cylinders. When it is decided to take a specimen from a cylinder, it is permissible for the specimen to be taken from one of the cylinders previously chosen for the mechanical tests specified in 3.1 or for the pressure bursting test specified in 3.2.

2.1.5. Heat and mechanical treatment of the alloys referred to in 2.1.2 (b) and (c).

2.1.5.1. The last process in the manufacture of the cylinder, apart from finish machining, shall be artificial ageing.

2.1.5.1.1. The manufacturer shall indicate the characteristics of the final treatment which he carries out, i.e.:

— nominal temperatures during solution and artificial ageing,

— nominal duration of the time effectively spent at solution and artificial ageing temperatures.

During the heat treatment the manufacturer must comply with these characteristics within the following limits:

— solution temperature: to within ± 5 °C,

— artificial ageing temperature: to within ± 5 °C,

— duration of time effectively spent: to within ± 10 %.

2.1.5.1.2. However, for solution and artificial ageing the manufacturer may indicate a range of temperatures, with the difference between the extreme values not exceeding 20 °C. For each of these extreme values, he shall indicate the nominal duration of the time effectively spent.

For each intermediate temperature the nominal duration of the time effectively spent shall be determined by linear interpolation for the duration of the placing in solution and by linear interpolation of the logarithm of the time for the duration of artificial ageing.

The manufacturer must carry out the heat treatment at a temperature included in the range indicated for a duration of time effectively spent, which shall not vary by more than 10 % from the nominal duration calculated as above.

2.1.5.1.3. The manufacturer must indicate the characteristics of the final heat treatment he has carried out, in the file submitted for the purposes of EEC verification.

2.1.5.1.4. In addition to the final heat treatment, the manufacturer must also indicate all heat treatments carried out at over 200 °C.

2.1.5.2. The manufacture of the cylinder may not include quenching and artificial ageing.

2.1.5.2.1. The manufacturer must specify the characteristics of the last heat treatment he has carried out at a temperature exceeding 200 °C, taking account of differences, if necessary, between different parts of the cylinder.

He must also specify any forming operation (e.g. extrusion, drawing or head formation) in the course of which the temperature of the metal does not exceed 200 °C and which is not followed by heat treatment at a temperature higher than that value, as well as the position of the section of the formed body which has undergone most cold-working and the corresponding degree of cold-working.

For the purposes of applying this provision, 'degree of cold-working' is defined as the ratio $\frac{S - s}{s}$, S being the initial section and s the final section.

The manufacturer must comply with these characteristics of the heat treatment and forming within the following limits:

— duration of the heat treatment to within ± 10 % and temperature to within ± 5 °C,

— degree of cold-working of the section which has undergone most cold-working to within ± 6 % if the diameter of the cylinder is equal to or less than 100 mm and to within ± 3 % if the diameter is more than 100 mm.

2.1.5.2.2. However, for the heat treatment the manufacturer may indicate a range of temperatures, with the difference between the extreme values not exceeding 20 °C. For each of these extreme values he shall indicate the nominal duration of the time effectively spent. For each intermediate temperature the nominal duration of the time effectively spent shall be determined by linear interpolation. The manufacturer must carry out the heat treatment at a temperature included in the range indicated for a duration of time effectively spent which shall not vary by more than 10 % from the nominal duration calculated as above.

2.1.5.2.3. The manufacturer must indicate the characteristics of the final heat treatment which he has carried out and of the forming process in the file submitted for the purposes of EEC verification.

2.1.5.3. Where the manufacturer has opted to indicate a range of temperatures for the heat treatment in accordance with 2.1.5.1.2 and 2.1.5.2.2, for the purpose of EEC pattern approval he must present two sets of cylinders, one made up of cylinders which have undergone the heat treatment at the lowest temperature of those envisaged and another made up of cylinders which have undergone the heat treatment at the highest temperature and with the shortest corresponding durations.

2.3. CALCULATION OF THE PRESSURE PARTS

2.3.1. The thickness of the cylindrical part of the gas cylinders must not be less than that calculated by means of the formula:

$$a = \frac{P_h \cdot D}{\frac{20\ R}{4/3} + P_h}$$

where R is the smaller of the following two values:

— R_e

— $0{,}85 \cdot R_m$.

2.3.2. The minimum wall thickness a may in no case be less than $\frac{D}{100} + 1{,}5$ mm.

2.3.3. The thickness and the shape of the bottom and the top ends must be such as to satisfy the requirements of the tests laid down in 3.2 (bursting test) and 3.3 (pressure cycling test).

2.3.4. In order to obtain satisfactory stress distribution, the thickness of the cylinder walls must increase progressively in the transition section between the cylindrical part and the base where the bottom is thicker than the cylindrical wall.

2.4. CONSTRUCTION AND WORKMANSHIP

2.4.1. The thickness of each cylinder must be checked and the condition of its internal and external surfaces inspected by the manufacturer in order to verify that:

— the wall thickness is at no point less than that specified on the drawing,

— the internal and external surfaces of the cylinder are free from defects which would adversely affect the operating safety of the cylinder.

2.4.2. The out-of-roundness of the cylindrical shell must be limited to a value which is such that the difference between the maximum and minimum outside diameters in the same cross section is not more than 1,5 % of the average of those diameters.

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

2.4.3. Cylinder footrings, where provided, must be sufficiently strong and be manufactured from a material which, with regard to corrosion, is compatible with the type of material of which the cylinder is made. The shape of the footring must give the cylinder an adequate degree of stability. Footrings must not allow water to accumulate or permit water to penetrate between the ring and the cylinder.

3. TESTS

3.1. MECHANICAL TESTS

Except for the requirements set out below, the mechanical tests shall be carried out in accordance with the following EURONORMS:

EURONORM 2-80: tensile test for steel;

EURONORM 3-79: Brinell hardness test;

EURONORM 6-55: bend test for steel;

EURONORM 11-80: tensile test for steel sheet and strip less than 3 mm thick;

EURONORM 12-55: bend test for steel sheet and strip less than 3 mm thick.

3.1.1. **General requirements**

All mechanical tests for checking the quality of the metal used for gas cylinders shall be carried out on metal taken from the finished cylinders.

3.1.2. **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 band tests in a circumferential direction.

3.1.2.1. *Tensile test*

3.1.2.1.1. The test-piece on which the tensile test is carried out must conform to the provisions of:

— chapter 4 of EURONORM 2-80, where it is 3 mm thick or more,

— chapter 4 of EURONORM 11-80, where it is less than 3 mm thick. In this case, the gauge width and length of the test-piece must be 12,5 and 50 mm respectively, irrespective of the thickness of the test-piece.

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

3.1.2.1.2. — With regard to the alloys C referred to in 2.1.2 (b) and the alloys referred to in 2.1.2 (c), elongation after fracture must not be less than 12 %.

— With regard to the alloys B referred to in 2.1.2 (b), the elongation after fracture must 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 must be as follows:

— no individual value may be less than 11 %,

— the average of the four measurements must be at least 12.

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

3.1.2.1.3. The value obtained for tensile strength must not be less than R_m.

The yield stress to be determined during the tensile test shall be that used in accordance with 1.1 for the cylinder calculation.

The value obtained for the yield stress must not be less than R_e.

3.1.2.2. *Bend test*

3.1.2.2.1. The bend test shall be carried out on test-pieces obtained by cutting a ring of width 3a into two equal parts; in no case may the width of the test-piece be less than 25 mm. Each ring may be machined only on the edges. The latter 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 %.

3.1.2.2.2. The bend test must be carried out using a mandrel of diameter d and two rollers separated by a distance of d + 3a. During the test the inside face of the ring must remain in contact with the mandrel.

3.1.2.2.3. The test-piece must not crack when bent inwards around a mandrel until the inside edges are no farther apart than the diameter of a mandrel (see diagram in Appendix 2).

3.1.2.2.4. The ratio (n) between the diameter of the mandrel and the thickness of the test-piece must not exceed the values given in the following table:

Actual tensile strength R_{mt} in N/mm²	Value of n
up to 220 inclusive	5
above 220 to 330 inclusive	6
above 330 to 440 inclusive	7
above 440	8

3.2. HYDRAULIC PRESSURE BURSTING TEST

3.2.1. **Test conditions**

Cylinders examined when this test is carried out must bear the markings specified in section 6 below.

3.2.1.1. The hydraulic pressure bursting test must be carried out in two successive stages, using a test-rig which allows pressure to be increased at an even rate until the cylinder bursts and the curve of pressure variation against time to be recorded. The test must be carried out at room temperature.

3.2.1.2. During the first stage, the increase in pressure shall be constant up to the level at which plastic deformation starts. This rate must not exceed 5 bars/sec.

From the start of plastic deformation (second stage), delivery from the pump must not be more than twice as much as it was in the first phase and must be maintained constant until the cylinder bursts.

3.2.2. **Interpretation of test**

3.2.2.1. The interpretation of the pressure bursting test shall involve:

— examination of the pressure/time curve to determine the bursting pressure,

— examination of the tear and of the shape of its edges,

— verification, in the case of cylinders with a concave base, that the base of the cylinder has not been reversed.

3.2.2.2. The measured bursting pressure (P_r) shall be greater than the value given by:

$$P_{rt} = \frac{20a\ R_m}{D - a}$$

3.2.2.3. The bursting test must not cause fragmentation of the cylinder.

3.2.2.4. The main tear must not be of the brittle type, i.e. the edges of the fracture must not be radial but be sloping in relation to a diametral plane and must display a contraction.

A fracture shall be acceptable only if it conforms to one of the following descriptions:

— for cylinders of a thickness a of 13 mm or less:

  — the greater part of the fracture must be unmistakably longitudinal,

  — the fracture must be without multiple branches,

— the facture must not have a circumferential development of more than 90° on either side of its main part,

— the fracture must not extend into those parts of the cylinder which are more than 1,5 times thicker than the maximum thickness measured halfway up the cylinder; however, for cylinders with convex bases the fracture must not reach the centre of the cylinder base;

— for cylinders of a thickness a of over 13 mm the greater part of the fracture must be longitudinal.

3.2.2.5. The tear shall not reveal any obvious defect in the metal.

3.3. PRESSURE CYCLING TEST

3.3.1. Cylinders subjected to this test must bear the markings specified in section 6.

3.3.2. The test shall be carried out using a non-corrosive fluid on two cylinders which are guaranteed by the manufacturer to be reasonably representative of the minimum values specified in the design.

3.3.3. This test shall be cyclical. The maximum cyclic pressure shall be equal to either the pressure P_h or two-thirds thereof.

The lower cyclic pressure must not exceed 10 % of the upper cyclic pressure.

The minimum number of cycles and the maximum test frequency are shown in the following table:

Maximum applied pressure	P_h	$^2/_3 P_h$
Minimum number of cycles	12 000	80 000
Maximum frequency in cycles per minute	5	12

The temperature measured on the outer wall of the cylinder must not exceed 50 °C during the test.

The test shall be considered satisfactory if the cylinder attains the required number of cycles without developing a leak.

3.4. HYDRAULIC TEST

3.4.1. The water pressure in the cylinder must increase at an even rate until the pressure P_h is reached.

3.4.2. The cylinder must remain under the pressure P_h long enough to make it possible to establish that the pressure shows no tendency to fall and that there are no leaks.

3.4.3. After the test the cylinder must show no permanent deformation.

3.4.4. Any tested cylinder which does not fulfil the test requirements shall be rejected.

3.5. CHECK ON THE HOMOGENEITY OF A CYLINDER

This test involves checking that any two points on the metal of the external surface of the cylinder do not differ in hardness by more than 15 HB. The check must be carried out on two transverse sections of the cylinder near the head and the base, at four evenly-spaced points.

3.6. CHECK ON THE HOMOGENEITY OF A BATCH

This test, which is carried out by the manufacturer, involves checking by means of a hardness test or some other appropriate means that no error has been made in the choice of the original billets or in carrying out the heat treatment.

3.7. CHECK OF BASES

A meridian section shall be made in the base of the cylinder and polished for examination at a magnification of between 5 and 10.

The cylinder must be regarded as defective if the presence of fissures is detected. It is also to be regarded as defective if the dimensions of any pores or inclusions present reach values considered to pose a threat to safety.

4. **EEC PATTERN APPROVAL**

The EEC pattern approval referred to in Article 4 of the Directive may be issued for types or for families of cylinders.

'Family of cylinders' means cylinders from the same factory differing only in length, but within the following limits:

— the minimum overall length must not be less than 3 times the external diameter of the cylinder,

— the maximum overall length must not be more than 1,5 times the overall length of the tested cylinder.

4.1. The applicant for EEC pattern approval shall, for each family of cylinders, submit the documentation necessary for the checks specified below and make available to the Member State a batch of 50 or two batches of 25 cylinders in accordance with 2.1.5.3, from which the number of cylinders required for the tests referred to below will be taken, together with any additional information required by the Member State.

In particular, the applicant must indicate the type of heat treatment and mechanical treatment, and the temperature and the duration of treatment under 2.1.5. He must provide cast analysis certificates for materials used in the manufacture of the cylinders.

4.2. In the course of the EEC pattern approval process, the Member State shall:

4.2.1. verify that:

— the calculations specified in 2.3 are correct,

— the thickness of the walls of two of the cylinders taken for tests meets the requirements of 2.3, the measurements being taken on three transverse sections and over the whole of the longitudinal sections of the base and the head,

— the requirements of 2.1 and 2.4.3 are complied with,

— the requirements of 2.4.2 are complied with for all cylinders selected by the Member State,

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

4.2.2. carry out the following tests on the cylinders selected:

— the tests for resistance to corrosion: intercrystalline corrosion and stress corrosion on 12 test-pieces as described in Annex II,

— the tests specified in 3.1, on two cylinders; however, where the length of the cylinder is 1 500 mm or more, the tensile tests in a longitudinal direction and the bend tests shall be carried out on test-pieces taken from the upper and lower regions of the shell,

— the test specified in 3.2, on two cylinders,

— the test specified in 3.3, on two cylinders,

— the test specified in 3.5, on one cylinder,

— the test specified in 3.7, on all the sample cylinders.

4.3. If the results of the checks are satisfactory, the Member State shall issue an EEC pattern approval certificate in accordance with the model given in Annex III to this Directive.

5. EEC VERIFICATION

5.1. For the purpose of EEC verification, the cylinder manufacturer shall provide the inspection body with:

5.1.1. the EEC pattern approval certificate;

5.1.2. cast ingot analysis certificates of the materials used for the manufacture of the cylinders;

5.1.3. means of identifying the cast of the material from which each cylinder was made;

5.1.4. the documents relating to heat treatment and mechanical treatment and state the treatment applied in accordance with 2.1.5;

5.1.5. a list of the cylinders, giving the numbers and inscriptions as required in section 6.

5.2. During EEC verification:

5.2.1. The inspection body shall:

— ascertain that the EEC pattern approval certificate has been obtained and that the cylinders conform to it,

— check the documents which give data concerning the materials,

— check whether the technical requirements set out in section 2 have been met, and in particular check by an external, and if possible internal, visual examination of the cylinders whether their construction and the checks carried out by the manufacturer in accordance with 2.4.1 are satisfactory; the visual examination shall cover at least 10 % of the cylinders manufactured,

— carry out the intercrystalline corrosion resistance test on three test-pieces, using one test-piece per section (head, body, base) in accordance with section 1 of Annex II on the alloys referred to in 2.1.2 (c) of this Annex,

— carry out the tests specified in 3.1 and 3.2,

— check whether the information supplied by the manufacturer in the list referred to in 5.1.5 is correct. This shall be done by means of a random check,

— assess the result of the checks on the homogeneity of the batch carried out by the manufacturer in accordance with 3.6.

If the results of the checks are satisfactory, the inspection body shall issue an EEC verification certificate conforming to the model given in Annex IV.

5.2.2. For the two types of test prescribed in 3.1 and 3.2, two cylinders shall be taken at random from each batch of 202 cylinders or part thereof that have been made from the same cast and have undergone the specified heat treatment in identical circumstances.

One of the cylinders shall be subjected to the tests in 3.1 (mechanical tests) and the other to the test prescribed in 3.2 (bursting test). If it is proved that a test has been carried out incorrectly or that a measuring error has been made, the test must be repeated.

If one or more tests prove even partially unsatisfactory the cause must be investigated by the manufacturer under the supervision of the inspection body.

5.2.2.1. If the failure is not due to the heat treatment applied, the batch must be rejected.

5.2.2.2. If the failure is due to the heat treatment applied, the manufacturer may subject all the cylinders in the batch to a further heat treatment. There may be only one such further treatment.

In that event:

— the manufacturer shall carry out the check provided for in 3.6,

— the inspection body shall carry out all the tests provided for in 5.2.2.

The results of the tests carried out following this further treatment must satisfy the requirements of this Directive.

5.2.3. The selection of specimens and all the tests shall be carried out in the presence and under the supervision of a representative of the inspection body. However, in respect of the test specified in the fourth indent of 5.2.1, the approved body may confine itself to being represented merely at the selection of specimens and examination of the results.

5.2.4. After all the tests specified have been carried out, all the cylinders in the batch must be subjected to the hydraulic test specified in 3.4 in the presence and under the supervision of a representative of the inspection body.

5.3. EXEMPTION FROM EEC VERIFICATION

In respect of the cylinders referred to in Article 4 of this Directive, and in accordance with Article 15 (a) of Directive 76/767/EEC, all the test and inspection operations prescribed in 5.2 must be carried out by the manufacturer on his own responsibility.

The manufacturer must provide the inspection body with all the documents mentioned in the EEC pattern approval and the test and inspection reports.

6. MARKS AND INSCRIPTIONS

The marks and inscriptions specified in this section must be affixed to the head of the cylinder.

In respect of cylinders with a capacity of not more than 15 litres the marks and inscriptions may be affixed either to the head or to a sufficiently strong part of the cylinder.

In respect of cylinders with a diameter of less than 75 mm, such marks must be 3 mm high.

Notwithstanding the requirements of section 3 of Annex I to Directive 76/767/EEC, the manufacturer must make the EEC pattern approval mark in the following order:

— for the cylinders referred to in Article 4 of this Directive:
  — the stylized letter $\mathcal{E}$,
  — the serial number 2 of this Directive,
  — the capital letter(s) identifying the Member State which has granted EEC pattern approval and the last two figures of the year in which the pattern approval was granted,
  — the number of the EEC pattern approval (e.g. $\mathcal{E}$ 2 D 79 45);

— for the cylinders subject only to EEC pattern approval:

  — the stylized letter ℰ surrounded by a hexagon,

  — the serial number 2 of this Directive,

  — the capital letter(s) identifying the Member State which has granted EEC pattern approval and the last two figures of the year in which the pattern approval was granted,

  — the number of the EEC pattern approval (e.g. ⟨ℰ⟩ 2 D 79 54).

Notwithstanding the requirements of section 3 of Annex II to Directive 76/767/EEC, the inspection body must affix the EEC verification mark in the following order:

— the small letter 'e',

— the capital letter(s) identifying the Member State in which the verification is carried out with, where necessary, one or two numbers identifying a territorial subdivision,

— the mark of the inspection body affixed by the verifying agent, together with the mark of the verifying agent if appropriate,

— a hexagon,

— the date of verification: year, month (e.g. e D 12 48 ⬡ 80/01).

6.1. INSCRIPTIONS RELATING TO THE CONSTRUCTION

6.1.1. **as regards the metal:**

a number indicating the value of R in N/mm² on which the calculation was based;

6.1.2. **as regards the hydraulic test:**

the test pressure in bars followed by the symbol 'bar';

6.1.3. **as regards the type of cylinder:**

the mass of the cylinder, including all integral parts but excluding valve and tap, in kilograms, and the minimum capacity guaranteed by the manufacturer of the cylinder in litres.

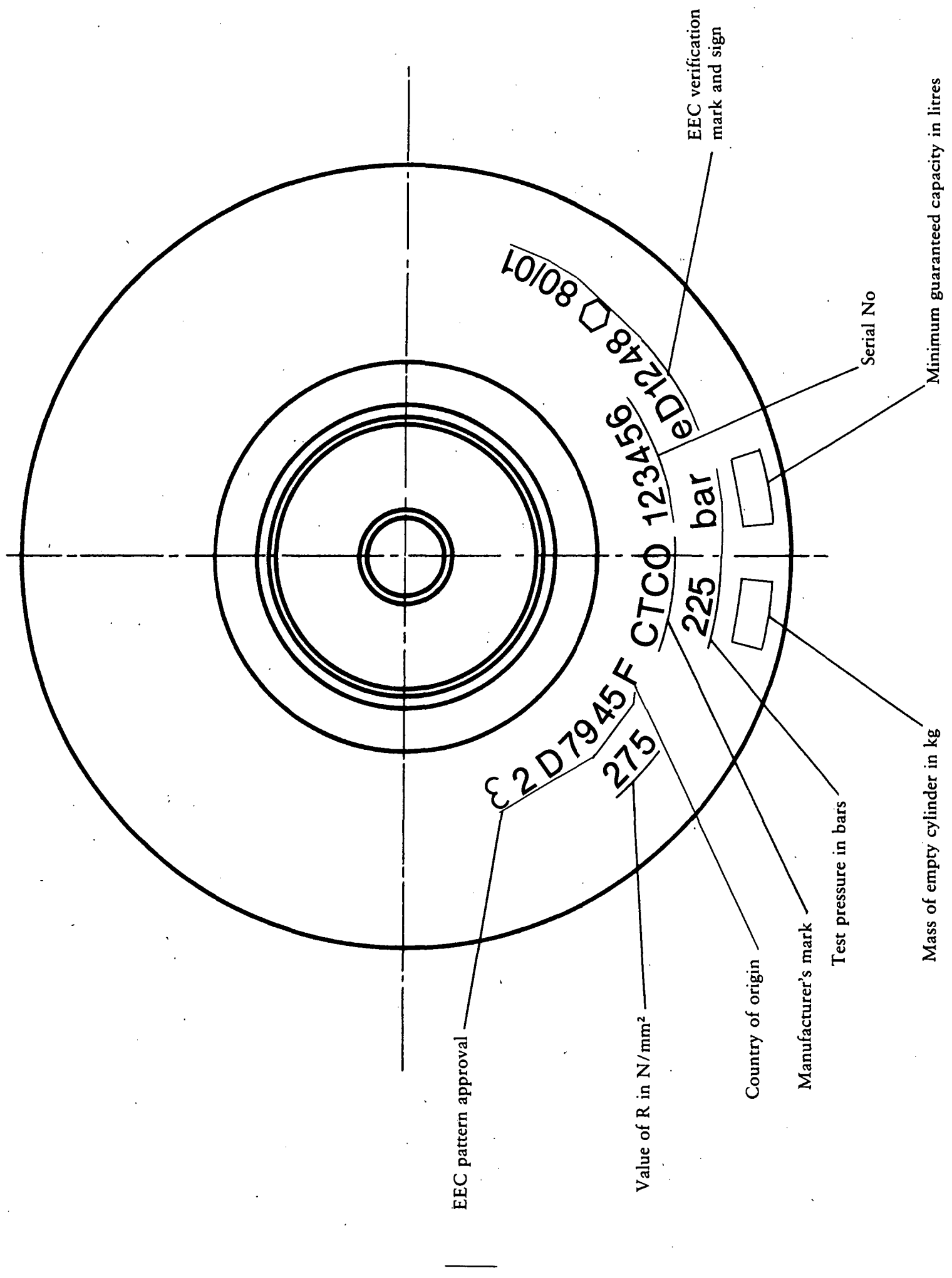
The figures for mass and capacity must be given to one decimal place. This value is to be rounded down for the capacity and up for the mass;

6.1.4. **as regards origin:**

the capital letter(s) indicating the country of origin, followed by the manufacturer's mark and the serial number.

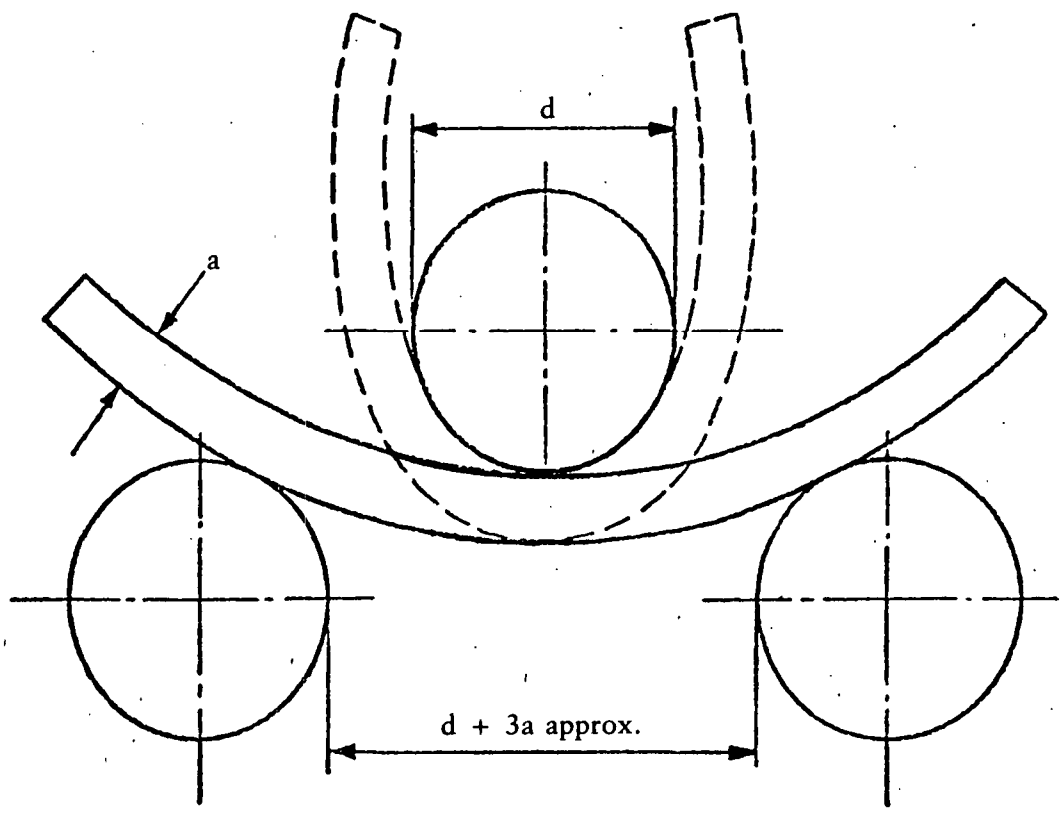
6.2. A diagram showing examples of the marks and inscriptions is given in Appendix 1.

Appendix 1


EEC verification mark and sign
Serial No
Minimum guaranteed capacity in litres
80/01
e D12 48
123459
CTCO
bar
225
E 2 D7945 F
275
EEC pattern approval
Value of R in N/mm²
Country of origin
Manufacturer's mark
Test pressure in bars
Mass of empty cylinder in kg

Appendix 2

Illustration of bend test



ANNEX II

CORROSION TESTS

1. TEST FOR ASSESSING SUSCEPTIBILITY TO INTERCRYSTALLINE CORROSION

The method described below consists of simultaneously immersing the specimens taken from the finished cylinder under test in two different corrosive solutions and examining them after a specified etching time in order to detect any signs of intercrystalline corrosion and determine the nature and degree of such corrosion. The propagation of intercrystalline corrosion is determined metallographically on polished surfaces cut transversely to the etched surface.

1.1. TAKING SPECIMENS

Specimens are taken from the head, body and base of the cylinder (figure 1), so that the tests with solution A as defined in 1.3.2.1 or solution B as defined in 1.3.2.2 can be carried out on metal from three parts of the cylinder.

Each specimen must be of the general shape and the dimensions indicated in figure 2.

The faces a1 a2 a3 a4, b1 b2 b3 b4, a1 a2 b2 b1, a4 a3 b3 b4 are all sawn with a band-saw and then carefully trimmed with a fine file. The surfaces a1 a4 b4 b1 and a2 a3 b3 b2 which correspond respectively to the inner and outer faces of the cylinder are left in their rough manufactured state.

1.2. PREPARATION OF SURFACE BEFORE CORROSIVE ETCHING

1.2.1. Products required

HNO_3 for analysis, density 1,33,

HF for analysis, density 1,14 (at 40 %),

de-ionized water.

1.2.2. Method

Prepare the following solution in a beaker:

HNO_3: 63 cm^3,

HF: 6 cm^3,

H_2O: 929 cm^3.

Bring the solution to a temperature of 95 °C.

Treat each specimen, suspended on an aluminium wire, in this solution for one minute.

Wash in running water and then in de-ionized water.

Immerse the specimen in nitric acid, as defined in 1.2.1, for 1 minute at room temperature to remove any copper deposit which may have formed.

Rinse in de-ionized water.

To prevent oxidation of specimens, they should be plunged, as soon as they have been prepared, in the corrosion bath intended for them (see 1.3.1).

1.3. PERFORMANCE OF TEST

1.3.1. One of the following two corrosive solutions is to be used, at the discretion of the inspection body: one with 57 g/l sodium chloride and 3 g/l hydrogen peroxide (solution A), and the other with 30 g/l sodium chloride and 5 g/l hydrochloric acid (solution B).

1.3.2. **Preparation of corrosive solutions**

1.3.2.1. *Solution A*

1.3.2.1.1. Products required

NaCl crystallized, for analysis,

H_2O_2 100 to 110 volumes — medicinal,

$KMnO_4$ for analysis,

H_2SO_4 for analysis, density 1,83,

de-ionized water.

1.3.2.1.2. Titration of hydrogen peroxide

Since hydrogen peroxide is not very stable, it is essential to check its titre each time before use. To do this:

take 10 cm^3 of hydrogen peroxide with a pipette, dilute to 1 000 cm^3 (in a gauged flask) with de-ionized water, thus obtaining a hydrogen peroxide solution which will be called C. With a pipette, place in an Erlenmeyer flask:

— 10 cm^3 of the hydrogen peroxide solution C,

— 2 cm^3 approximately of sulphuric acid, density 1,83.

A solution of permanganate at 1,859 g/l is used for the titration. The permanganate itself serves as an indicator.

1.3.2.1.3. Explanation of titration

The reaction of the permanganate on the hydrogen peroxide in a sulphuric medium is expressed as:

$$2\ KMnO_4 + 5\ H_2O_2 + 3\ H_2SO_4 \longrightarrow K_2SO_4 + 2\ MnSO_4 + 8\ H_2O + 5\ O_2$$

which gives the equivalence: 316 g $KMnO_4$ = 170 g H_2O_2.

Therefore 1 g of pure hydrogen peroxide reacts on 1 859 g of permanganate; hence the use of a 1,859 g/l solution of permanganate, which saturates, volume for volume, 1 g/l hydrogen peroxide. Since the hydrogen peroxide was diluted 100 times to begin with, the 10 cm^3 of the test sample represent 0,1 cm^3 of the original hydrogen peroxide.

By multiplying by 10 the number of cubic centimetres of permanganate solution used for the titration, the titre T of the original hydrogen peroxide in g/l is obtained.

1.3.2.1.4. Preparation of the solution

Method for 10 litres:

Dissolve 570 g of sodium chloride in de-ionized water to obtain a total volume of about 9 litres. Add the quantity of hydrogen peroxide calculated below. Mix and then make up the volume to 10 litres with de-ionized water.

Calculation of the volume of hydrogen peroxide to be put into the solution

Quantity of pure hydrogen peroxide required: 30 g.

If the hydrogen peroxide contains T grams of H_2O_2 per litre, the volume required, expressed in cubic centimetres, will be:

$$\frac{1\,000 \cdot 30}{T}$$

1.3.2.2. *Solution B*

1.3.2.2.1. Products required:

NaCl, crystallized, for analysis,

HCl, pure concentrated, 37 % HCl,

de-ionized water.

1.3.2.2.2. Preparation of the solution:

Method for 10 l of solution:

Dissolve 300 g of sodium chloride and 50 g of HCl (50 g = 0,5 %) in 9 l of de-ionized water, mix well and make up to 10 l.

1.3.3. **Etching conditions**

1.3.3.1. *Etching in solution A*

The corrosive solution is placed in a crystallizer (or possibly a large beaker), itself placed in a water bath. The water bath is stirred with a magnetic stirrer and the temperature is regulated with a contact thermometer.

The specimen is either suspended in the corrosive solution by means of an aluminium wire or placed in the solution so that it rests only on the corners, the second method being preferable. The etching time is six hours and the temperature fixed at 30 ± 1 °C. Care should be taken to ensure that the quantity of reagent is at least 10 cm^3 per cm^2 of specimen surface.

After etching, the specimen is washed in water, immersed for about 30 seconds in 50 % dilute nitric acid, washed again in water and dried with compressed air.

1.3.3.2. A number of specimens can be etched at the same time provided that they are of the same type of alloy and that they are not in contact. The minimum quantity of reagent per unit of specimen surface must, of course, be adhered to.

1.3.3.3. *Etching in solution B*

The corrosive solution is poured into a suitable glass container (e.g. a beaker). The test is carried out at room temperature. If it is impossible to avoid variations in room temperature during the test, it is preferable to carry out the test in a water bath, the temperature of which is adjusted to 23 °C by means of a thermostat. Etching time is 72 hours.

The fixing of specimens in the corrosive solution is in accordance with 2.3.1. After etching, the specimens are very carefully washed with de-ionized water and dried with greasefree compressed air. Care must in any event be taken to see that the ratio of quantity of corrosive solution to specimen surface in ml/cm^2 is 10 : 1 (see 2.3.1).

1.4. PREPARATION OF SPECIMENS FOR EXAMINATION

1.4.1. **Products required**

Casting dishes with, for example, the following dimensions:

— external diameter: 40 mm,

— height: 27 mm,

— wall thickness: 2,5 mm,

Araldite DCY 230 } or equivalent.
hardener HY 951 }

1.4.2. **Method**

Each specimen is placed vertically in a casting dish so that it rests on its face a1 a2 a3 a4. Around it is poured a mixture of Araldite DCY 230 and hardener HY 951 in the proportion 9 to 1.

The setting time is about 24 hours.

A certain amount of material is removed from the face a1 a2 a3 a4, preferably by lathe, so that the section a'1 a'2 a'3 a'4 examined under the microscope cannot show corrosion from the surface a1 a2 a3 a4. The distance between the faces a1 a2 a3 a4 and a'1 a'2 a'3 a'4 i.e. the thickness removed by the lathe, must be at least 2 mm (figures 2 and 3).

The section for examination is polished mechanically with alumina first on paper and then on felt.

1.5. MICROGRAPHIC EXAMINATION OF SPECIMENS

The examination consists of noting the intensity of intercrystalline corrosion on the part of the perimeter of the section to be examined under 1.6. When doing this, account is taken of the properties of the metal both on the outer and inner surfaces of the cylinder and in the thickness of the latter.

The section is first examined at low magnification (× 40 for example) in order to locate the most corroded areas, and then at a higher magnification, usually about × 300, in order to assess the nature and extent of the corrosion.

1.6. INTERPRETATION OF THE MICROGRAPHIC EXAMINATION

This consists in verifying that intergranular corrosion is superficial:

1. for alloys with equiaxed crystallization, the depth of corrosion round the entire perimeter of the section must not exceed the higher of the following two values:

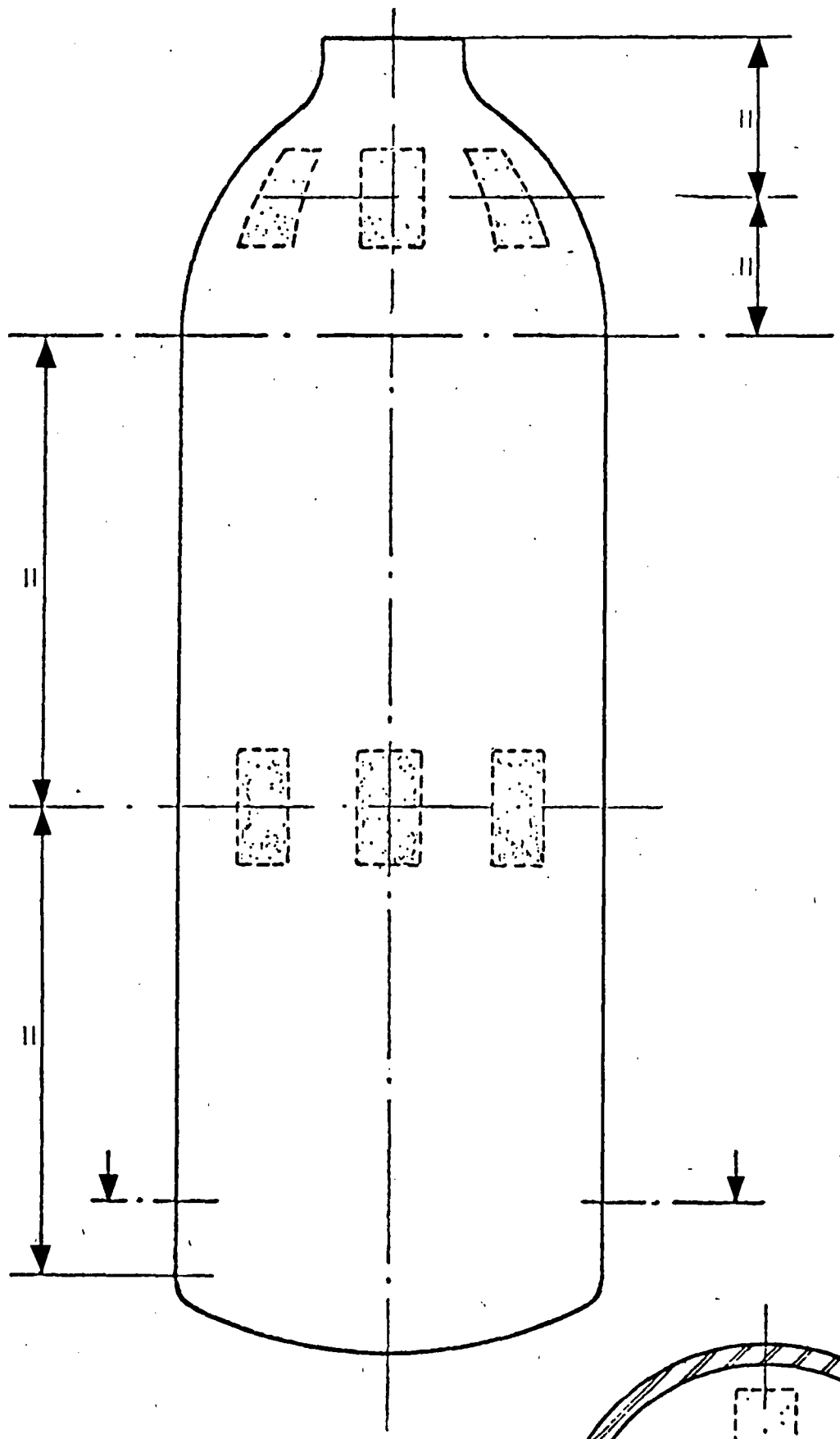
   — three grains in the direction perpendicular to the face examined,

   — 0,2 mm;

   However, it is permissible for these values to be exceeded locally provided that they are not exceeded in more than four fields of examination at × 300 magnification;

2. for alloys with crystallization set in one direction through cold-working, the depth of the corrosion into each of the two faces which make up the internal and external surfaces of the cylinder must not exceed 0,1 mm.

Appendix 1



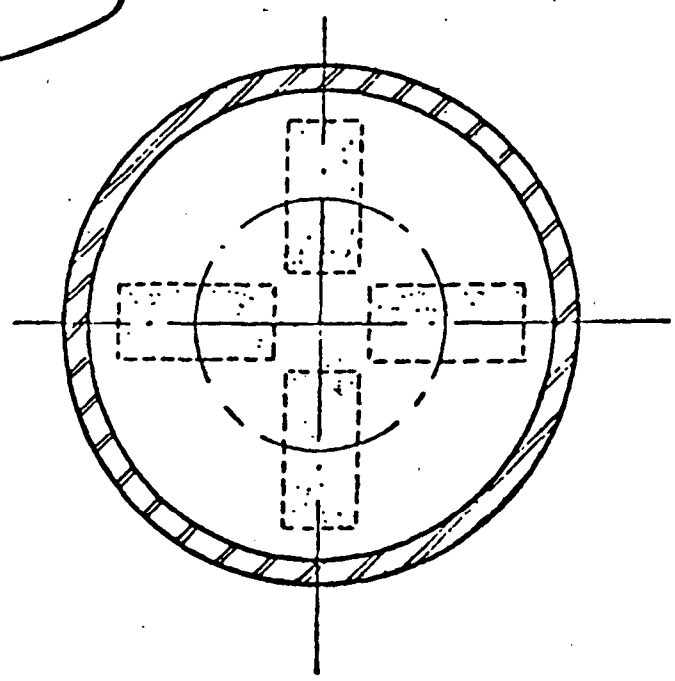


Figure 1

Appendix 2

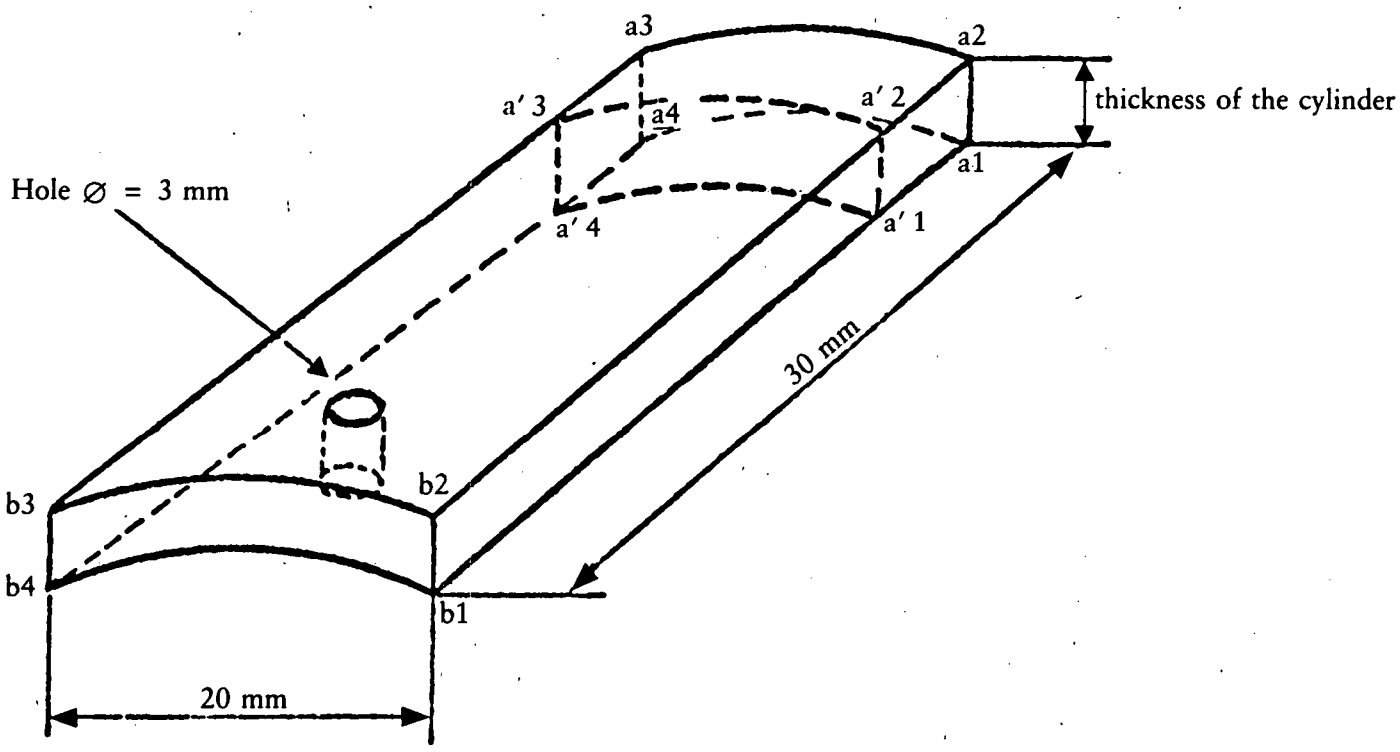


Figure 2

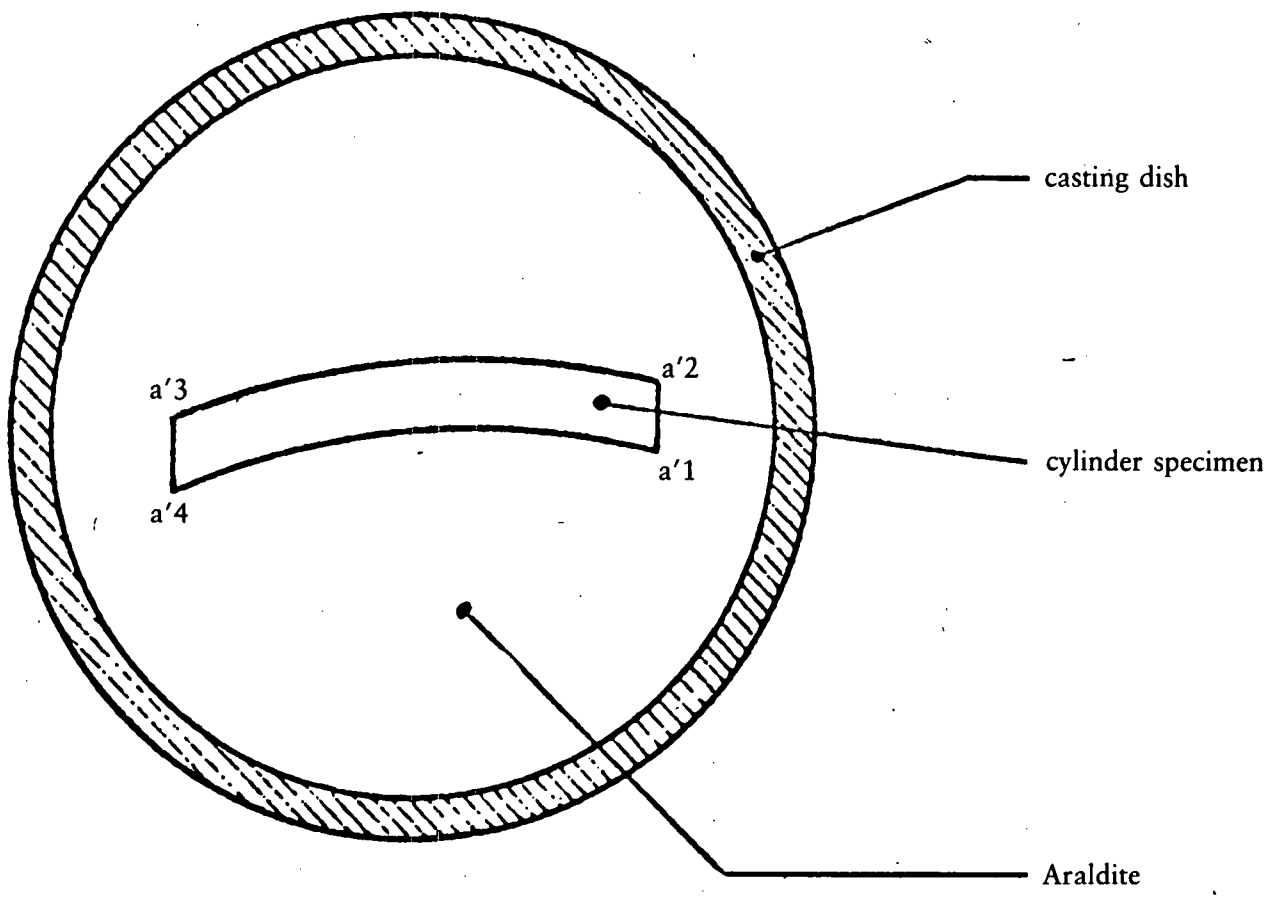


Figure 3

2. **TESTS FOR ASSESSING SUSCEPTIBILITY TO STRESS CORROSION**

The method described below consists of the subjection of rings cut from the cylindrical part of the cylinder to stress, their immersion in brine for a specified period, followed by removal of the brine and exposure to the air for a longer period and repetition of this cycle for 30 days. If there are no cracks in the rings after the period of 30 days, the alloy can be considered suitable for the manufacture of gas cylinders.

2.1. TAKING SPECIMENS

Six rings with a width of 4a or 25 mm, whichever is the greater, are to be cut from the cylindrical part of the cylinder (see figure 1). The specimens must have a 60° cut-out and be subjected to stress by means of a threaded bolt and two nuts (see figure 2).

Neither inner nor outer surfaces of the specimens are to be machined.

2.2. SURFACE PREPARATION BEFORE CORROSION TEST

All traces of grease, oil and adhesive used with stress gauges (see 2.3.2.4) must be removed with a suitable solvent.

2.3. PERFORMANCE OF THE TEST

2.3.1. **Preparation of the corrosive solution**

2.3.1.1. The brine is prepared by dissolving 3,5 ± 0,1 parts by mass of sodium chloride in 96,5 parts by mass of water.

2.3.1.2. The pH value of the freshly prepared solution must be in the range 6,4 to 7,2.

2.3.1.3. The pH may be corrected only by using dilute hydrochloric acid or dilute soda.

2.3.1.4. The solution must not be topped up by adding the salt solution described in 2.3.1.1 but only by adding distilled water up to the initial level in the vessel. Topping up may be carried out daily if necessary.

2.3.1.5. The solution must be completely replaced every week.

2.3.2. **Applying the stress to the rings**

2.3.2.1. Three rings are to be compressed so that the outer surface is under stress.

2.3.2.2. Three rings are to be opened so that the inner surface is under stress.

2.3.2.3. The amount of stress must be the maximum permissible stress in the following wall-thickness calculation:

$\frac{R_e}{1,3}$ where Re is the guaranteed minimum value of the yield stress at 0,2 % in N/mm².

2.3.2.4. The actual stress can be measured by electric stress gauges.

2.3.2.5. The stress can also be calculated using the following formula:

$$D^1 = D \pm \frac{\pi R(D - a)^2}{4Eaz},$$

in which

D^1 = diameter of the ring when compressed (or opened);

D = external diameter of the cylinder in mm;

a = cylinder wall thickness in mm;

$R = \frac{R_e}{1,3}$ N/mm²;

E = modulus of elasticity in N/mm² ≐ 70 000 N/mm²;

z = correction factor (figure 3).

2.3.2.6. It is essential for the nuts and bolts to be electrically insulated from the rings and protected from corrosion by the solution.

2.3.2.7. The six rings must be completely immersed in the saline solution for 10 minutes.

2.3.2.8. They are then removed from the solution and exposed to the air for 50 minutes.

2.3.2.9. This cycle must be repeated for 30 days or until the ring breaks, whichever happens first.

2.3.2.10. The specimens are to be inspected visually for any cracks.

2.4. INTERPRETATION OF THE RESULTS

The alloy will be considered acceptable for the manufacture of gas cylinders if none of the rings subjected to stress develops any cracks visible to the naked eye, or visible at low magnification (10 to 30), at the end of the test: 30 days.

2.5. POSSIBLE METALLOGRAPHICAL EXAMINATION

2.5.1. In the event of doubt about the presence of cracks (e.g. line of pitting), uncertainty can be removed by means of an additional metallographical examination of a section taken perpendicular to the axis of the ring in the suspect area. A comparison is made of the form (inter- or transcrystalline) and depth of penetration of the corrosion on the faces of the ring subject to tensile and compressive stress.

2.5.2. The alloy will be considered acceptable if the corrosion on both faces of the ring is similar.

On the other hand, if the face of the ring subject to tensile stress reveals inter-crystalline cracks which are clearly deeper than the corrosion affecting the face subject to compressive stress, the ring can be considered to have failed the test.

2.6. REPORTS

2.6.1. The name of the alloy and/or its standard number must be indicated.

2.6.2. Composition limits of the alloy must be given.

2.6.3. The actual analysis of the cast from which the cylinders were manufactured must be mentioned.

2.6.4. The actual mechanical properties of the alloy must be reported, together with the minimum mechanical property requirements.

2.6.5. The results of the test must be given.

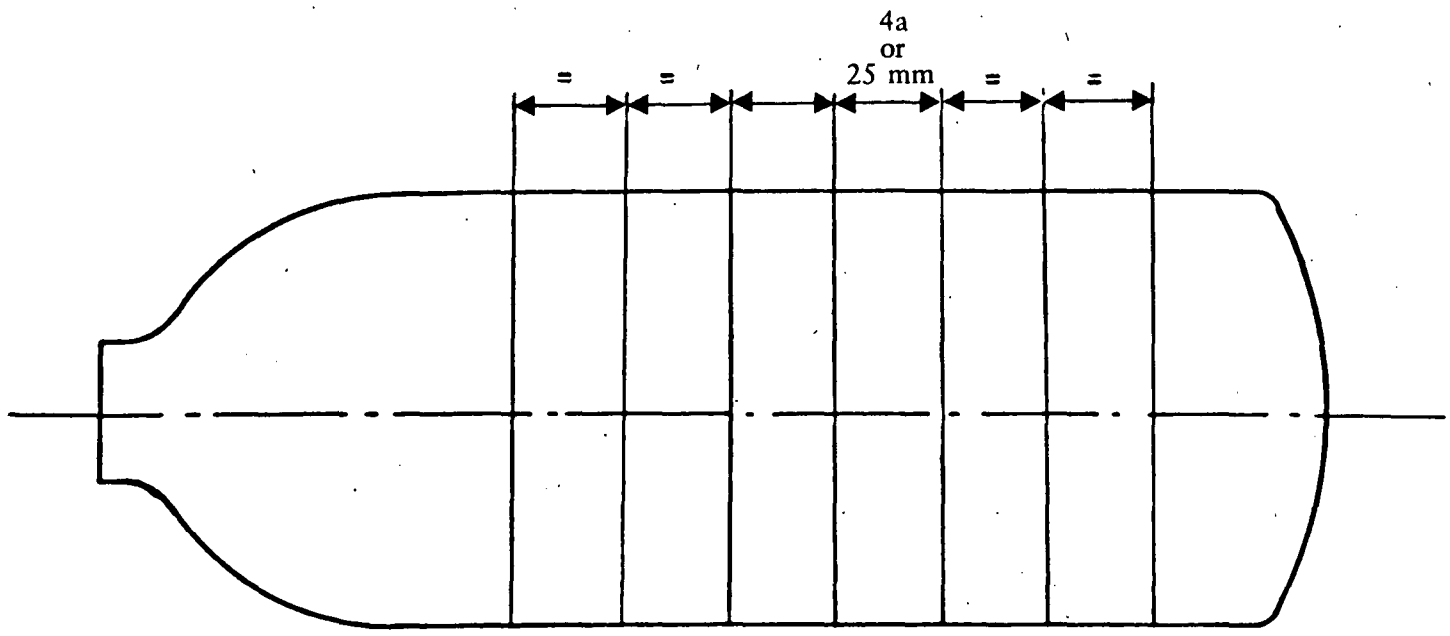


Figure 1

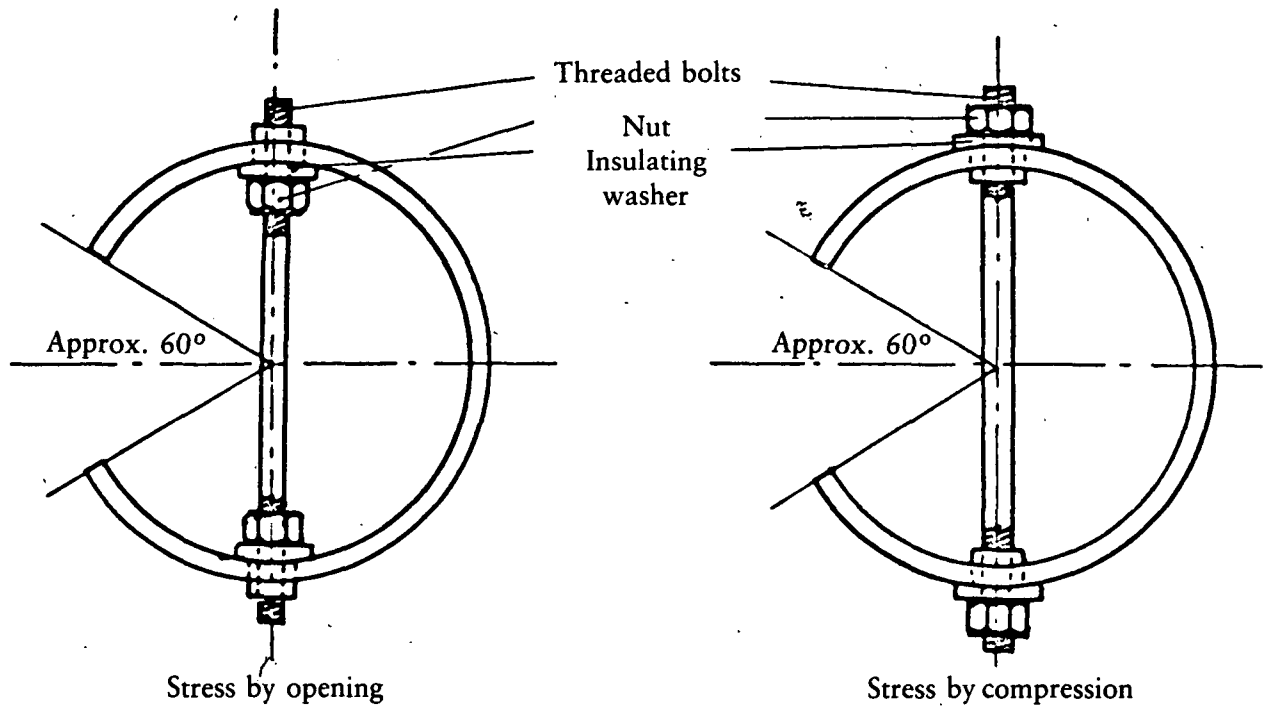


Figure 2

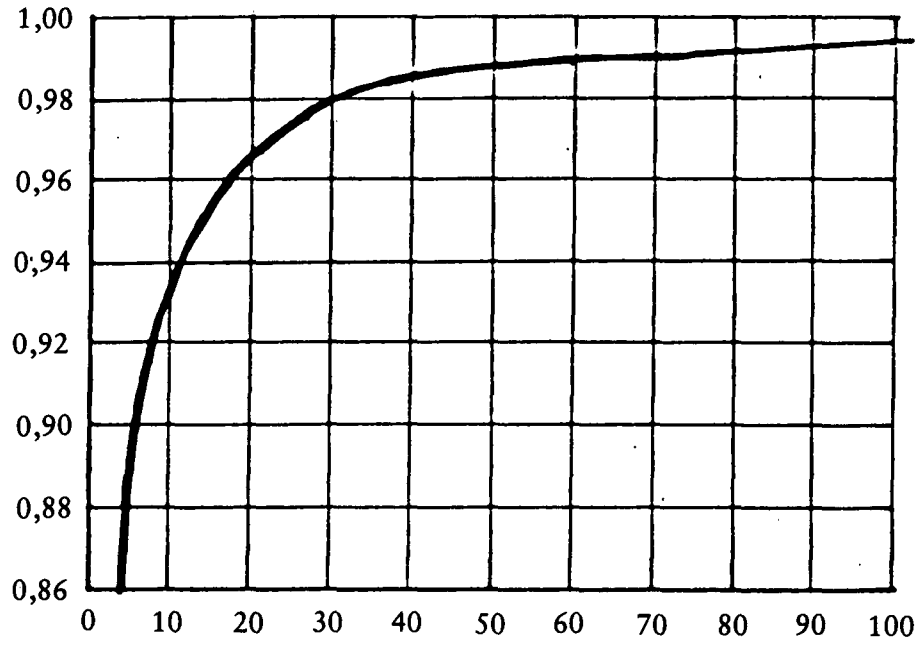


Figure 3

ANNEX III

EEC PATTERN APPROVAL CERTIFICATE

Issued by ..... on the basis of
(Member State)

.....
(National rules)

applying Directive 84/526/EEC of 17 September 1984 concerning

SEAMLESS, UNALLOYED ALUMINIUM AND ALUMINIUM ALLOY GAS CYLINDERS

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

Type of cylinder .....
(Description of the family of cylinders which has received EEC approval)

P_h ..... D ..... a .....

L_{min} ..... L_{max} ..... V_{min} ..... V_{max} .....

Manufacturer or agent .....
(Name and address of manufacturer or his agent)

.....

.....

.....

EEC pattern approval mark ε ..... ⟨ε⟩ .....

Details of the results of the examination of the pattern for EEC approval and the main features of the pattern are annexed.

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

.....

.....

.....

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

.....
(Signature)

TECHNICAL ANNEX TO EEC PATTERN APPROVAL CERTIFICATE

1. Results of EEC examination of the pattern with a view to EEC approval.

2. Main features of the pattern, in particular:

   — longitudinal cross-section of the type of cylinder which has received pattern approval, showing:

      — the nominal external diameter, D, with an indication of the design tolerances laid down by the manufacturer,

      — the minimum thickness of the cylinder wall, a,

      — the minimum thickness of the base and the head, with an indication of the design tolerances laid down by the manufacturer,

      — the minimum and maximum length(s), L_{min}, L_{max};

   — the capacity or capacities, V_{min}, V_{max};

   — the pressure, P_h;

   — the name of the manufacturer/No of the drawing and date;

   — name of the type of cylinder;

   — the alloy in accordance with section 2.1 (nature/chemical composition/method of manufacture/heat treatment/guaranteed mechanical characteristics (tensile strength — yield point)).

ANNEX IV

MODEL

EEC VERIFICATION CERTIFICATE

Application of Council Directive 84/526/EEC of 17 September 1984

Inspection body .....

.....

Date .....

EEC pattern approval No .....

Description of vessels .....

.....

EEC verification No .....

Manufacturing batch No ..... to .....

Manufacturer .....
(Name and address)

.....

.....

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

Owner .....
(Name and address)

.....

.....

Customer .....
(Name and address)

.....

.....

VERIFICATION TESTS

1. MEASUREMENTS OF SAMPLE CYLINDERS

Test No	Batch consisting of No ..... to No	Water capacity (litres)	Mass empty (kg)	Minimum measured thickness	
				of the wall (mm)	of the base (mm)

2. MECHANICAL TESTS CARRIED OUT ON SAMPLE CYLINDERS

Test No	Heat treatment No	Tensile test				Bend test 180 ° without cracking	Hydraulic bursting test (bars)	Description of the fracture (Description or diagram attached)
		Test-piece in accordance with EURONORM (a) 2-80 (b) 11-80	Yield point R_e (N/mm²)	Tensile strength R_{mt} (N/mm²)	Elongation A (%)			
Minimum values specified								

I, the undersigned, hereby declare that I have checked that the verification operations, tests and checks prescribed in section 5.2 of Annex I to Directive 84/527/EEC have been carried out successfully.

Special remarks .....

.....

General remarks .....

.....

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

.....
(Signature of the inspector)

on behalf of .....
(Inspection body)