II

(Preparatory Acts)

COMMISSION

Proposal for a Council Directive on the approximation of the laws of the Member States relating to certain types of simple pressure vessels

(Submitted by the Commission to the Council on 18 December 1978)

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,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the Economic and Social Committee,

Whereas in each Member State mandatory provisions determine the characteristics of construction and verification of unfired welded steel pressure vessels of simple geometry; whereas these requirements differ from one Member State to another; whereas such differences hinder trade, thus directly affecting the functioning of the common market;

Whereas Council Directive 76/767/EEC [1] of 27 July 1976 laid down in particular the procedures of EEC pattern approval and EEC verification to which such pressure vessels are subject;

Whereas, in accordance with that Directive, it is necessary to determine the technical requirements which the said pressure vessels must satisfy in order to be placed on the market and taken into service after an inspection and the affixing of the prescribed marks;

Whereas, in order to take account of technical progress, the technical requirements relating to pressure vessels must be adapted promptly; whereas the procedure laid down in Article 20 of the Directive must be applied;

Whereas pressure vessels may deviate in design and in the method of their manufacture from certain requirements, notably those laid down in 2.1 to 2.4 of the Annex, provided that they are no less safe; whereas the procedure laid down to that end in the Directive must accordingly be applied,

HAS ADOPTED THIS DIRECTIVE:

Article 1

1. This Directive shall apply to all fixed or movable unfired welded steel pressure vessels of simple geometry, as defined in Article 2, intended to contain compressed air or non-corrosive, non-toxic compressed gases.

2. The pressure vessels referred to in the first paragraph are hereinafter called 'vessels'.

3. The following are excluded:

— specially designed vessels for the conveyance of gases,

[1] OJ No L 262, 27. 9. 1976, p. 153.

— vessels intended to equip the brake circuits of motor vehicles and their trailers,

— fire-extinguisher vessels.

Article 2

For the purpose of this Directive, 'vessel' means any vessel:

(a) — comprising a right cylindrical portion with axisymmetrical dished heads on the same axis, the concave sides of which face inwards, or with flat heads,

— comprising two axisymmetrical dished heads on the same axis;

(b) having only circular penetrations and nozzles (though for cleaning or inspection purposes, in particular, these may be elliptical) with axes perpendicular to the wall of the cylindrical portion of the vessel and sufficiently far apart to be considered separately for purposes of stress analysis.

However, penetrations, notably for drainage purposes, may be provided on the walls of the dished heads as long as they are not more than 15 mm in diameter. Such penetrations need not be perpendicular to the walls of the dished heads.

The dished heads referred to in this Article shall be of one piece.

Article 3

The vessels referred to in Article 1 shall be subject to:

(a) EEC pattern approval and EEC verification where the product of P × V(1) exceeds 200 bar × litres;

(b) EEC verification where the product of P × V does not exceed 200 bar × litres.

(1) P = pressure, V = volume.

Article 4

The amendments necessary to adapt the Annex and Appendices to technical progress shall be adopted in accordance with the procedure laid down in Article 20 of Directive 76/767/EEC.

Article 5

Derogations from the provisions of 2.1 to 2.4 of the Annex may be granted pursuant to Article 17 of Directive 76/767/EEC.

Article 6

No Member State shall, on grounds relating to its design and inspection, refuse, prohibit or restrict the placing on the market and taking into service of a vessel which complies with the requirements of Directive 76/767/EEC and of the present Directive.

Article 7

1. Each Member State shall, within 18 months after notification of this Directive, bring into force the laws, regulations and administrative provisions necessary in order to comply therewith and shall forthwith inform the Commission thereof.

2. With effect from the notification of this Directive, each Member State shall ensure that every draft law, regulation or administrative provision that it is intended to adopt in the field covered by this Directive is notified to the Commission in good time to enable it to comment thereon.

Article 8

This Directive is addressed to the Member States.

TECHNICAL ANNEX

CHAPTER I

DESIGN OF VESSELS

1. **Limits of application**

The technical Annex of this Directive applies to the vessels referred to in Article 1 for which:

— the maximum working pressure does not exceed 30 bar,

— the volume does not exceed 3 000 litres,

— the product P × V does not exceed 10 000 bar × litres,

— the actual thickness of the shell rings and dished ends does not exceed 16 mm,

— the actual thickness of the shell rings and dished ends is not less than 2 mm,

— the actual thickness of the flat end plates does not exceed 25 mm,

— the length of the cylindrical part does not exceed 12 times its average diameter,

— the diameter of the openings does not exceed 0·3 times the average diameter of the cylindrical part,

— the diameter of the flanges does not exceed 300 mm,

— the circular or elliptical inspection openings do not exceed 400 mm at their widest point,

— the minimum working temperature is not less than — 20 or — 10 °C,

— the maximum working temperature does not exceed + 300 °C.

2. **Materials**

Castings may not under any circumstances be used for the manufacture of the pressure parts.

2.1. Pressure parts

The steels used for the fabrication of the pressure parts must meet the following conditions.

2.1.1. Vessels required to have a minimum working temperature of — 20 °C.

The grades and qualities of steel required are as follows:

(a) plate

Euronorm 28-69:	Fe 37-2 kW; Fe 37-2 kP; Fe 42-2 kW; Fe 42-2 kP; Fe 47-2 kW; Fe 47-2 kP;

(b) seamless tubes

standard ISO/2604/II-1975:	TS 6; TS 10; TS 15;

(c) welded tubes

standard ISO/2604/III-1975:	TW 6; TW 10; TW 15;

(d) forgings

standard ISO/2604/I-1975:	F 9;

(e) projections

Euronorm 25-72:	Fe 360 D; Fe 430 D.

2.1.2. Vessels required to have a minimum working temperature of — 10 °C.

The grades and qualities of steel required are as follows:

(a) plate

Euronorm 28-69: Fe 37; Fe 42;

(b) seamless tubes

standard ISO/2604/II-1975: TS 4; TS 6; TS 10; TS 13; TS 14; TS 15;

(c) welded tubes

standard ISO/2604/III-1975: TW 4, TW 5, TW 6, TW 9; TW 10; TW 13; TW 14; TW 15;

(d) forgings

standard ISO/2604/I-1975: F 8; F 9;

(e) projections

Euronorm 25-72: Fe 310; Fe 360; Fe 430.

2.2. Welded flanges: these shall be made of steel of the grade and quality specified in 2.1 or of a carbon or carbon-manganese steel of which the chemical composition of the melt and the mechanical properties fall within the limit values shown in the table below.

% C max.	% Mn max.	% Si max.	% S or % P max.	R_E max. N/mm²	R_R max. N/mm²	Elongation min. (%)
0·20	1·6	0·40	0·05	265	440	22

2.3. Fastenings

The bolts, screws, studs and nuts must conform to the specifications of ISO standards R898/I — 1968, R898/II — 1969 and 898/IV — 1972.

The categories of steel specified in these standards may be used provided that the minimum elongation after rupture of these steels is not less than 16 %.

2.4. Attachments

All unpressurized parts welded to the body of the vessel shall be of materials compatible with the steel of the vessel to which they are welded.

2.5. Ordering

2.5.1. When ordering the base materials, the vessel manufacturer shall specify the type of product together with its dimensions, characteristic and the grade and quality of the steel.

2.5.2. He shall also specify the type of documents which must accompany the delivery in accordance with 2.6 of this Directive.

2.6. Type of documents

2.6.1. Inspection certificate

The inspection certificate in accordance with the provisions of Euronorm 21-76 is required for the steel specified in 2.1.

2.6.2. Certificate of conformity with the order

The certificate of conformity with the order, in accordance with the provisions of Euronorm 21-76, is required for the steels specified in 2.2 and the products referred to in 2.4 of this Directive.

2.6.3. The documents referred to in 2.6.1 and 2.6.2 shall indicate the marks affixed to the products delivered in such a way that the documents can be correlated with the products without risk of error.

2.7. Identification

All the products used in the manufacture of the pressure vessels shall be identifiable.

3. Calculation of pressure parts

3.1. Definitions

3.1.1. Design pressure

This is the pressure value selected by the manufacturer, on his own responsibility, and used in the formulae for calculating the pressure parts.

3.1.2. Design temperature

This is a temperature value selected by the manufacturer on his own responsibility. It enables the stress value to be determined at the temperature concerned.

3.2. Thickness of the pressure parts

The thickness of the pressure parts shall not be less than those calculated with the formulae given in Annex I.

In these formulae no allowance is made for corrosion thickness. If, however, an allowance is made for extra thickness to take account of corrosion, the amount of such an allowance shall be indicated on the data plate affixed to the vessel.

3.2.1. The permissible stress f to be used in the formulae for calculating the pressure parts shall be whichever is the lower of the following values:

$$\frac{R_{ET}}{1{\cdot}5} \text{ or } \frac{R_R}{2{\cdot}5}$$

The yield strength R_{ET} used to calculate the permissible stress of the parts under pressure shall be one of the following values:

— when a steel does not have an upper and lower yield point, the normal proof stress $R_{0.2}$ is taken,

— when a steel has a lower and upper yield point, the value to be taken is either:

— R_eL

or

0·92 R_eH provided that the value R_eH has been determined from the load-extension diagram,

or

$R_{0.2}$,

— when the design temperature is above 50 °C, the yield strength is taken as the 0·2 % proof stress at the temperature concerned.

3.2.2. For butt welds the coefficient z used to calculate the pressure parts shall be taken as equal to:

— z = 1; z = 0·85 or z = 0·7.

CHAPTER II

MANUFACTURE VESSEL

4. **General**

4.1. The base products, the filler products, the welding and fabricating processes and the inspection methods shall be such as to ensure that the vessels produced satisfy the requirements of this Directive.

4.2. The welding techniques employed must have undergone an acceptance test beforehand in accordance with the provisions of Annex III.

4.3. The welds must be effected by welders who are qualified in accordance with the provisions of Annex V.

4.4. Any welding procedure ensuring complete penetration is permissible.

4.5. Inspection holes and flanges

If inspection holes or flanges are required, they shall be carried out in accordance with the specifications in sections 5 and 6 of Annex I.

5. **Preparation and welding of assemblies under pressure**

5.1. Forming of the plate

The forming of the plate shall not give rise to defects that might be detrimental to safety.

A forming process during which the temperature of the metal is below the transformation point AC_3 is known as cold forming.

In the case of cold forming, if the value

$$\frac{e_r}{2R_i} \times 100 \text{ is greater than } 3$$

normalizing heat treatment must be given.

e_r: actual thickness of the plate,

r_i: the smallest radius of curvature.

5.2. Bevelling of plate

Where plates of different thickness are welded by a circumferential butt weld, the thickness plate must be bevelled over a length not less than three times the width of the bevel.

5.3. Welding of plate

Only butt welds with complete penetration are permissible for the circumferential and longitudinal welds.

However, circumferential welds with hammered edges are permissible if the thickness of the plates does not exceed 8 mm.

For longitudinal joints, if a backing plate is used it must be removed after welding and before non-destructive testing.

For circumferential joints, if a backing plate is used and cannot be removed, satisfactory penetration of the backing plate must be ensured.

When backing plates are removed, they must not cause excessive deformation.

The material of the backing plate must be a kind which does not adversely affect the weld.

Connections between nozzles or penetrations and the shell ring and between the shell ring and/or the flat end plates in the case of fillet welds shall be such as to ensure complete fusion at the root.

5.4. Alignment of the plates

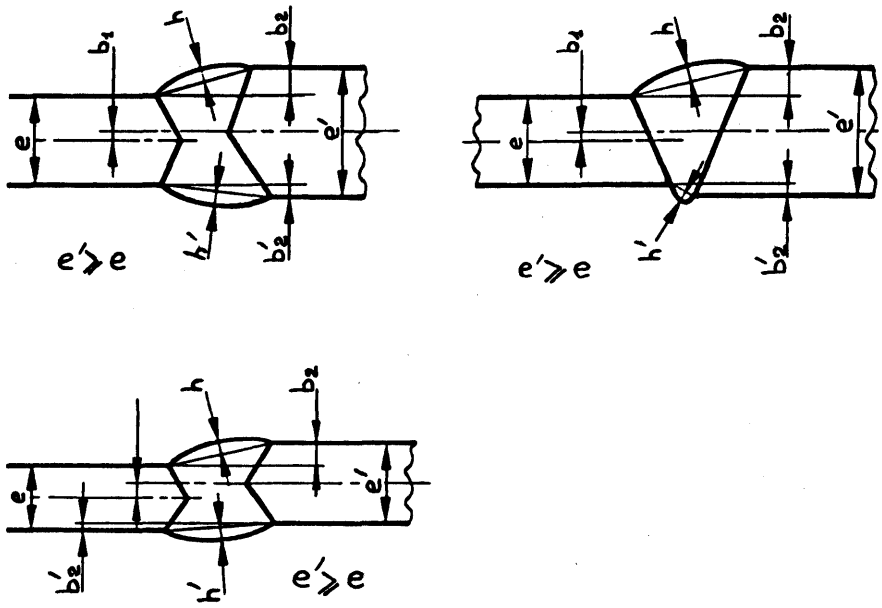
5.4.1. For longitudinal joints and for circumferential joints welded on one side only, the median axes of the plates shall be aligned with a tolerance of ± 10 % of the thickness of the thickest plate.

In the case of a circumferential joint welded in both sides, a larger tolerance is permissible provided a sound bead is obtained on the other side.

5.4.2. Alignment of surfaces with plates of different thicknesses.

The maximum error in the alignment of the surfaces of the plates is one quarter of the thickness of the thickest plate.

If this error is exceeded, the surface shall be bevelled in accordance with the specifications in 5.2.



Longitudinal joints	Circumferential joints
$b_1 \leqslant e'/10$	Welded on one side only: $b_1 \leqslant e'/10$ Welded on two sides: no limit
$b_2 \leqslant e'/4$ for $e' \leqslant 16$ mm	$b_2 \leqslant e'/4$ if $e' \leqslant 16$ mm
$h_1 \leqslant 3$ mm for $e' \leqslant 16$ mm	

5.5. Appearance of weld bead

All welds must have a regular surface and display no lack of thickness; they must blend with the surfaces of the plates without undercuts or unacceptable faults.

The weld reinforcement must not exceed the higher of the following two values: one tenth of the width of the bead or 1 mm. A double reinforcement is permissible at the point of overlap at the end of the bead.

The maximum height of the sealing run bead, if any, is the higher of the following two values: one tenth of the thickness of the plate or 1 mm.

5.6. Repairs to welds

The weld must be entirely renewed after removal of the defective section and not repaired by refilling.

With the exception of local retouching by manual welding, all repairs must be carried out by the same process as used for the original weld.

No other process may be used until the inspection authorities have been notified, have given their consent and have approved the process.

5.7. Shape tolerance

5.7.1. Ovality

The defect of ovality is defined by the difference between the maximum and minimum diameters divided by half their sum.

This ratio must not exceed 1 % in any cross section of the vessel. At the nozzle locations, however, an ovality of up to 2 % is acceptable.

5.7.2. Straightness

The deflection of any generatrix of the cylindrical part of the vessel when empty and not under pressure must not exceed 0·3 %.

5.7.3. Irregularities of profile

Irregularities in the profile (checked by means of a gauge with a 20° aperture) must not exceed 5 % of the minimum thickness of the plate plus 3 mm. This maximum value shall be increased by 25 % if the length of the irregularity does not exceed one quarter of the length of the cylindrical shell component contained between two circumferential joints, with a maximum of 1 m.

6. **Welding of accessories not subject to pressure**

The design of accessories such as supports, handles, hoisting eyes, stiffeners, etc. must be such as to allow them to be welded to pressure parts. Welding must be carried out in accordance with the specifications in 5.5.

CHAPTER III

EEC PATTERN APPROVAL

7. **Application for EEC pattern approval**

The application and the correspondence relating to it must comply with the requirements laid down in section 1 of Annex I to Council Directive 76/767/EEC of 27 July 1976.

8. **Examination for EEC pattern approval**

8.1. The examination for EEC pattern approval shall be carried out on the basis of the technical file and specimen vessels.

8.2. — The applicant shall make available 10 vessels representative of the planned production. The inspection body shall select three vessels on which the prescribed verification and tests will be carried out.

However, for vessels produced in small quantities, the applicant shall make available the number of vessels required for the verifications and tests stipulated in this Directive.

— For vessels to be produced in small quantities, the applicant shall make available the number of vessels considered necessary by the inspection body for the verifications and tests stipulated in this Directive.

8.3. Examination of the technical file

This examination shall include:

(a) verification that the steels have been selected in accordance with the requirements laid down in 2.1, 2.2, 2.3 and 2.4;

(b) checking of the conformity documents specified in 2.6;

(c) checking of the design of the vessels in accordance with the requirements laid down in Annex I, sections 5 and 6;

(d) checking of the location provided for the EEC marks and inscriptions in accordance with Chapter V;

(e) verification of the certificates for the welding technique and the welders' qualifications required for the welding methods to be used for production;

(f) verification that the design calculations have been carried out in accordance with the requirements laid down in section 3 and in Annex I, sections 1, 2, 3 and 4.

8.4. Inspections and tests to be performed on finished vessels.

8.4.1. Test on finished vessels

(a) 100 % radiographic examination of the butt welds on the vessels made available to the inspection body;

(b) one hydrostatic test on each vessel selected by the inspection body;

(c) a pressure cycling test on one vessel of the vessel to be produced have flat end plates and fillet welds.

8.4.2. Checks on good workmanship

The checks on good workmanship shall include in particular:

— checking of the design of the welded joints in accordance with the requirements of sections 4, 5 and 6,

— checking of the thickness of the pressure parts in accordance with the requirements of section 3 and of Annex I, sections 1, 2, 3 and 4.

8.5. Inspections and tests to be performed on specimens taken from a finished vessel.

The specimens shall be taken at the factory by the manufacturer in the presence of the inspection body.

8.5.1. Tests on rings

The following tests shall be carried out on the rings which have been heat-treated:

(a) one tensile test;

(b) three impact tests.

8.5.2. Test on vessel ends

The following tests shall be carried out on vessel ends in all cases:

(a) one tensile test;

(b) three impact tests.

8.5.3. Test to be performed on welds

8.5.3.1. Longitudinal and circumferential welds

The following tests shall be performed, at the discretion of the inspection body, on either the longitudinal welds or the circumferential welds when the welding technique used is the same for both.

When this is not the case, the tests shall be performed on both circumferential and longitudinal welds

(a) one tensile test (perpendicular to the weld);

(b) one bend test on the underside of the weld;

(c) one bend test on the upper side of the weld;

(d) three impact tests in the weld;

(e) three impact tests in the heat-affected zone limited according to the diameter and thickness of the ring;

(f) one hardness test;

(g) one macrographic examination.

8.5.3.2. Nozzle, penetration and ring/flat-end welds

Ultrasonic inspection of these welds shall be performed on each vessel made available to the inspection body.

A macrographic examination shall be carried out on nozzle and penetration welds.

This examination shall also be carried out on ring/flat-end welds where a fillet weld is used.

8.5.4. The impact tests for EEC pattern approval shall be carried out at — 20 °C if the minimum working temperature is — 20 °C and at 0 °C if the minimum working temperature is — 10 °C.

These tests shall be carried out if the plate is more than 5 mm thick.

9. **EEC pattern approval certificate and mark**

The EEC pattern approval certificate and the accompanying technical file must reproduce the requirements specified in section 3 of Annex I to Council Directive 76/767/EEC.

The certificate must be in accordance with the specimen set out in Annex VI to this Directive.

The certificate must contain in particular:

— the conclusions of the pattern examination,

— the expiry date of the EEC pattern approval in accordance with 10.3,

— the conditions which must be satisfied by the variants of a vessel in order that they may be covered by the same EEC pattern approval in accordance with 10.2,

— the marks relating to the EEC pattern approval in accordance with section 5 of Annex I to Council Directive 76/767/EEC and 14.1 of this Directive.

10. **Characteristics of vessels covered by the same EEC type approval**

10.1. EEC type approval may be granted for vessels consisting of:

(a) two ends and one or more rings; or

(b) two dished ends for which a cylindrical edge is provided in accordance with the requirements of section 2 of Annex I.

10.2. The EEC pattern approval granted for one model of vessel may cover variants of this model.

A family of vessels consists of one or more variants.

Vessels which differ from the model only in diameter and/or in the length of their cylindrical part within the following limits form part of the same family:

(a) Variations in diameter

— variations in diameter are permitted but the actual thicknesses of the walls of the vessels in any one family must be identical to the thicknesses of the walls of the model,

— variations must meet the requirements in 3.2,

— the conditions regarding heat treatment in 5.1 must be observed;

(b) Variations in the length of the cylindrical part

— When the model consists of one or more shell rings in addition to the ends, vessels in the same family must also consist of one or more shell rings,

— when the model consists solely of two dished ends in accordance with 10.1 (b), vessels in the same family may not under any circumstances contain one or more shell rings,

— if variations in the length of the vessel involve modifications in respect of openings and penetrations (number, dimensions, spacing), these modifications shall be shown on the drawing of each variant submitted with the application for pattern approval and must meet the conditions laid down in this Directive.

10.3. The period of validity of an EEC pattern approval certificate for these vessels shall be:

(a) vessels subject to pattern approval:

— five years, which may be extended by the Member State granting approval for successive periods of a maximum of five years;

(b) vessels subject to pattern approval and verification:

— 10 years, which may be extended by the Member State granting approval for successive periods of a maximum of 10 years.

CHAPTER IV

EEC PATTERN VERIFICATION

11. **Examination for conformity to an approved pattern**

At the time of EEC verification, the inspection body shall verify that each vessel in the batch conforms to the approved pattern, particularly as regards:

— the principal dimensions, the specified inscriptions, the pattern approval mark and the location provided for the EEC verification marks in accordance with section 14,

— the validity of the certificates obtained regarding approval of the welding technique(s) and the qualifications of the welders,

— the requirements specified in 5.4 to 5.7,

— the inspection body shall verify that the materials used are as specified in the technical file accompanying the EEC pattern approval certificate in accordance with the requirements in 2.7.

12. **Test to be performed on coupon plates**

The coupon plate shall be taken in the presence of the inspection body.

For each batch or part of 25 vessels built, a coupon plate representative of the batch or part thereof shall be supplied.

For mass production, the number of vessels per batch shall be decided by the inspection body.

The dimensions of the coupon plate shall be such that it is possible to take from it a sufficient number of test pieces on which to perform the specified tests.

12.1. Tests on welds

The following test shall be carried out:

(a) one tensile test (perpendicular to the weld);

(b) one bend test on the underside of the weld;

(c) one bend test on the upper side of the weld;

(d) three impact tests in the weld.

— When a different welding technique is used for longitudinal and circumferential welds, these tests shall be carried out on both types of weld,

— when the same technique is used for longitudinal and circumferential welds, these tests shall be carried out on the longitudinal welds in each batch and on the circumferential welds in every second batch,

— the impact tests stipulated for EEC pattern verification shall be carried out at — 20 °C if the minimum working temperature is — 20 °C and at 0 °C if the minimum working temperature is — 10 °C.

These tests shall be carried out if the plate is more than 5 mm thick.

13. **Non-destructive testing of vessels**

13.1. Radiographic examination

The radiographic examination of butt welds shall be carried out in accordance with the requirements of Annex II under the following conditions:

if Z = 1	100 % radiographic examination of the welds for all vessels in the batch;
if Z = 0·85	all welds made by the same technique shall be given a radiographic examination over 5 % of their length. This examination may be performed on one or more vessels but on each occasion the junctions of the main welds shall be included. However the percentage may be reduced to 2 % if at least one vessel is given a 100 % examination daily.
if Z = 0·7	radiography is not required.

13.2. Hydrostatic test

This test shall be carried out in accordance with the requirements of 3.2 of Annex II on every vessel in the batch.

13.3. Penetrant fluid weld test

This test shall be carried out in accordance with the requirements of 2.4 in Annex II on nozzle and penetration welds and on ring/flat-end fillet welds on one vessel in each batch.

13.4. EEC pattern verification certificate and mark

If the results of the inspection are satisfactory, the inspection body shall issue the EEC verification certificate.

The EEC verification certificate shall contain the information required by section 3 of Annex II to Council Directive 76/767/EEC.

CHAPTER V

DATA PLATES

14. Marks, EEC symbols and inscriptions

Nothing must be stamped on the wall of the pressure parts of the vessel. The marks and inscriptions stipulated below shall be shown on to a data plate.

A non-detachable data plate shall be placed on each vessel in a position that is visible when the vessel is installed.

14.1. EEC pattern approval marks

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

(a) for the vessel referred to in Article 3 (a) of the Directive:

— the stylized letter ε,

— the number . . . denoting this Directive,

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

— the EEC pattern approval number,

— example: ε 4F8453;

(b) for the vessels referred to in Article 3 (b) of the Directive:

— the stylized letter ε surrounded by a hexagon,

— the number . . . denoting this Directive,

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

— the EEC pattern approval number,

— example: ⟨ε⟩ 4F8453.

14.2. EEC verification marks

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

— the small letter 'e',

— the capital letter(s) identifying the State in which the verification is carried out together, where necessary, with 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 surrounding hexagon,

— the verification date: year, month, day,

— example: e F 1248 ⟨⟩ 84/12/11.

14.3. Inscriptions

— the value of the test pressure on the form: P_h = . . . bar,

— the value of the design pressure in the form: P = . . . bar,

— the design temperature in the form: T = ... °C,

— the minimum working temperature in the form: T_{min} = ... °C,

— the extra corrosion allowance in the form: S = ... mm,

— the volume of the vessel in the form: V = ... l,

— the name or mark of the manufacturer or person responsible for placing the vessel on the market,

— the manufacturer's serial number.

14.4. A specimen diagram of the marks and inscriptions is given below.

ℰ 4 F 84 53	e F 12 48 ⬡ 84/12/11
P_h = 15 bar	P = 10 bar
T = 200 °C	T_{min} = — 10 °C
S = 1 mm	V = 2 000 l
Name/mark:	
No: SC 7592 B	

ANNEX I

CALCULATION OF PRESSURE PARTS AND DIMENSIONING OF APERTURES

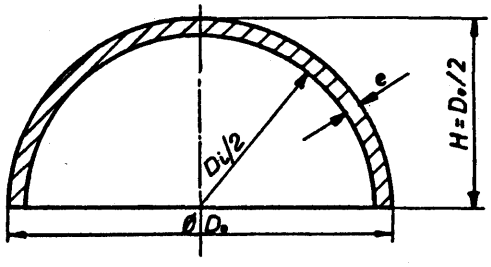
I.1. Calculation of cylindrical shell rings

The minimum thickness for pressure resistance is calculated by the following formula:

$$e = \frac{P\,D_i}{20\,fZ - P}$$

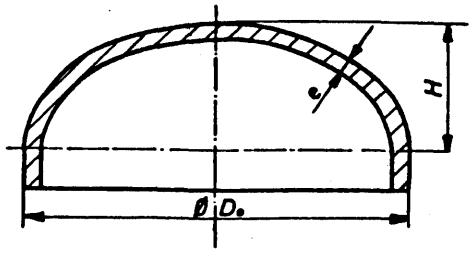
I.2. Calculation of dished ends

Figure I.1
Hemispherical end-plates



$0{\cdot}003\ D_o \leq e \leq 0{\cdot}16\ D_o$

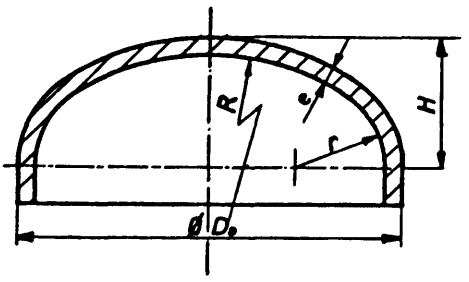
Figure I.2
Elliptical end-plates



Simultaneous limitations
$0{\cdot}003\ D_o \leq e \leq 0{\cdot}08\ D_o$
$H \geq 0{\cdot}18\ D_o$

Figure I.3
Torispherical end-plates

Simultaneous limitations:
$0{\cdot}003\,D_o \leq e \leq 0{\cdot}08\,D_o$
$r \geq 0{\cdot}1\,D_o$
$R_i \leq D_o$
$H \geq 0{\cdot}18\,D_o$
$r \geq 2\,e$



The minimum thickness of these dished ends is calculated by the following formula:

$$e = \frac{P\,D_o}{20\,f}\,C$$

In addition, the thickness of a torispherical end-plate must not be less than:

$$e = \frac{P\,R}{20\,f - 0{\cdot}5\,P}$$

The shape factor C to be used for solid ends is given in Table I.1. Figure I.4 contains a graphical representation of the values of C as a function of H/D for different values of P/10 f.

With the exception of hemispherical end-plates, all ends of a thickness less than the thickness of the shell ring shall be provided with a cylindrical edge of a length not exceeding three times its thickness or 50 mm.

Shape factor C for dished heads

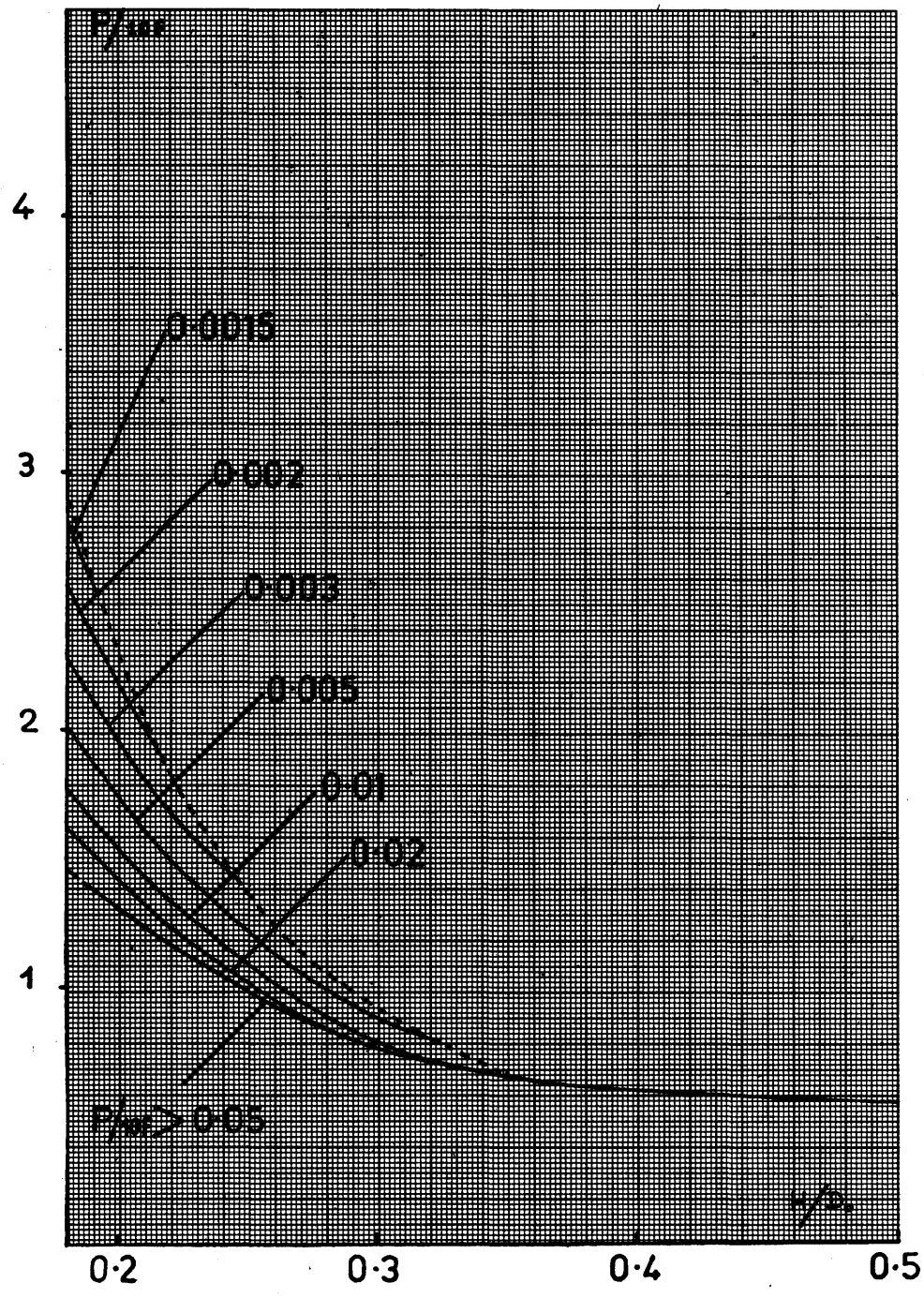


Figure I.4

TABLE I.1

	P/10 f = 0·001		P/10 f = 0·0012		P/10 f = 0·0015		P/10 f = 0·002	
H/D_o	e/D_o	C	e/D_o	C	e/D_o	C	e/D_o	C
0·180					0·00211	2·81	0·00255	2·55
0·200							0·00218	2·18
	P/10 f = 0·003		P/10 f = 0·004		P/10 f = 0·005		P/10 f = 0·01	
H/D_o	e/D_o	C	e/D_o	C	e/D_o	C	e/D_o	C
0·180	0·00340	2·27	0·00423	2·12	0·00500	2·00	0·0088	1·76
0·190	0·00316	2·11	0·00395	1·98				
0·200	0·00290	1·93	0·00364	1·82	0·00433	1·73	0·0077	1·54
0·210	0·00273	1·82	0·00342	1·71				
0·220	0·00256	1·71	0·00320	1·60	0·00382	1·53	0·0068	1·38
0·230	0·00236	1·57	0·00295	1·48				
0·240	0·00220	1·47	0·00276	1·38				
0·250					0·00307	1·23	0·0055	1·10
0·300					0·00220	0·88	0·00395	0·79
0·350							0·00325	0·65
0·400							0·0030	0·60
0·450							0·0028	0·56
0·500							0·0027	0·54
	P/10 f = 0·02		P/10 f = 0·05		P/10 f = 0·1		P/10 f = 0·2	
H/D_o	e/D_o	C	e/D_o	C	e/D_o	C	e/D_o	C
0·180	0·0160	1·60	0·0366	1·46	0·0730	1·46	0·147	1·47
0·200	0·0141	1·41	0·0330	1·32	0·0650	1·30	0·130	1·30
0·220	0·0125	1·25	0·0292	1·17	0·0585	1·17	0·118	1·18
0·250	0·0102	1·02	0·0250	1·00	0·0500	1·00	0·101	1·01
0·300	0·0077	0·77	0·0193	0·77	0·0385	0·77	0·077	0·77
0·350	0·0065	0·65	0·0162	0·65	0·0325	0·65	0·065	0·65
0·400	0·0059	0·59	0·0149	0·60	0·0295	0·59	0·059	0·59
0·450	0·0056	0·56	0·0140	0·56	0·0280	0·56	0·056	0·56
0·500	0·0054	0·54	0·0136	0·54	0·0270	0·54	0·054	0·54
	P/10 f = 0·5							
H/D_o	e/D_o	C						
0·350	0·163	0·65						
0·400	0·150	0·60						
0·450	0·140	0·56						
0·500	0·136	0·54						

I.3. Calculation of flat end-plates

The minimum thickness of an unreinforced flat end-plate without aperture is calculated by the following formula:

$$e_f = C_1 D_i \sqrt{\frac{P}{10\,f}}$$

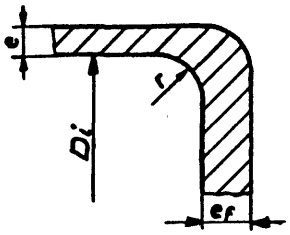
in which C_1 is a shape factor which must have the following values:

— C_1 = 0·45 for the ends represented by Figures I.5, I.6 and I.7,

— C_1 = 0·5 for the ends represented by Figure I.8.

Figure I.5

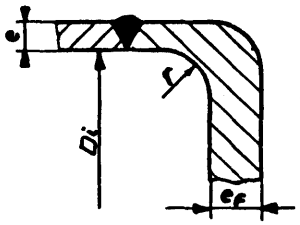
Cylindrical body sealed by forging



$r \geq 0{\cdot}25\ e_f$
$r \geq 5$ mm

Figure I.6

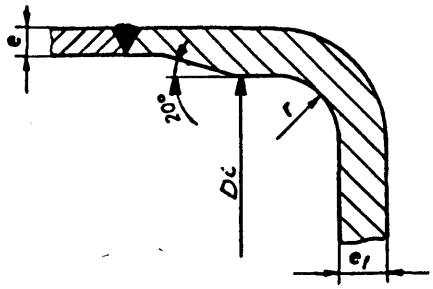
End machined from a forged blank



$r \geq 1{\cdot}5\ e_f$

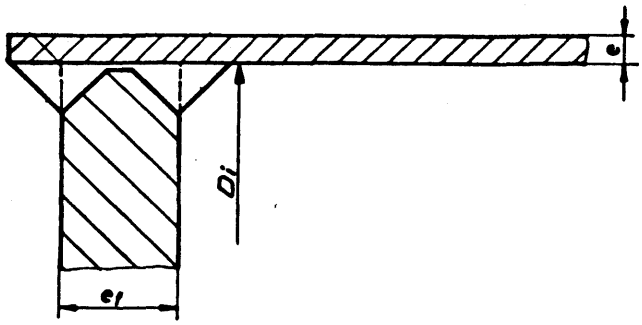
Figure I.7

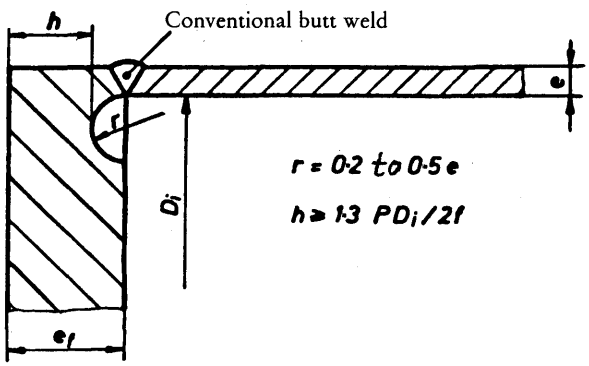
Deep-drawn flat end-plate



$0{\cdot}25\ e_f \leq r \leq 2\ e_f$
$r \geq 5$ mm

Unbraced flat end-plates





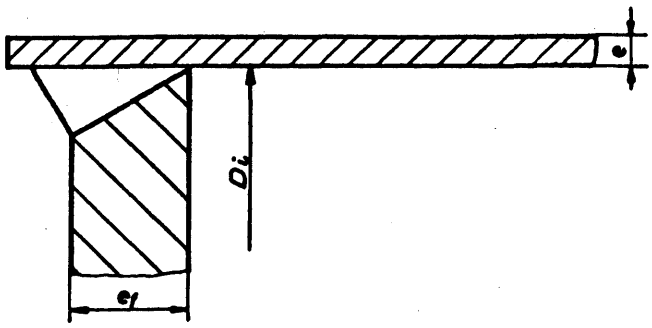


Figure I.8

I.4. Dimensioning of apertures in a cylindrical or spherical part.

The diameter of the apertures shall not exceed 0·3 times the average diameter of the cylindrical part.

The thickness e_o of the wall in the vicinity of an aperture must not be less than:

$$e_o = \frac{P\,D_i}{20\,fZ_o - P}$$

The different types of stiffening that can be used are shown in Figures I.9 to I.13.

Figure I.9

Type I: general increase in wall thickness

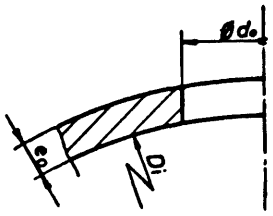


Figure I.10

Type II: by a stiffening ring

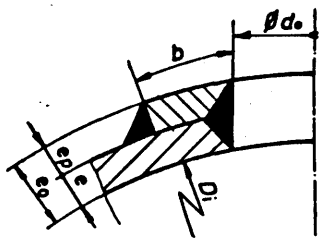
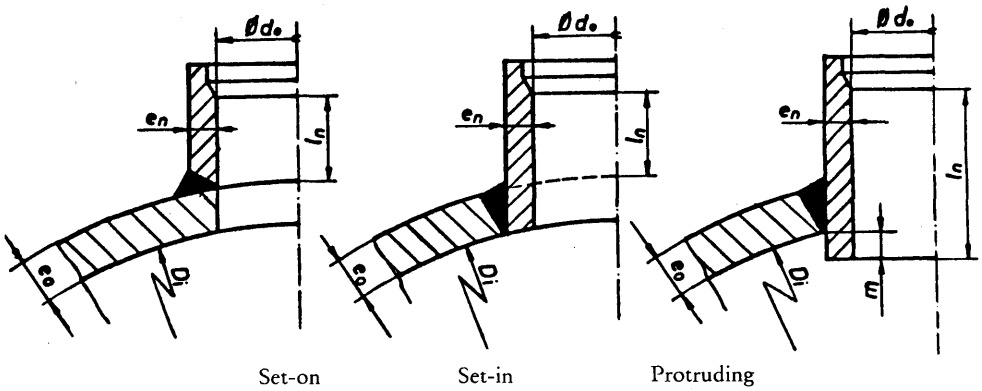


Figure I.11

Type III: by a welded nozzle

The following three cases are possible:



Set-on Set-in Protruding

Figure I.12

Type IV: by an extruded nozzle

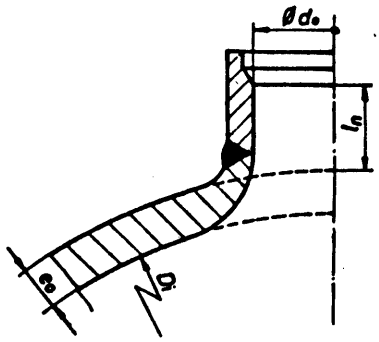
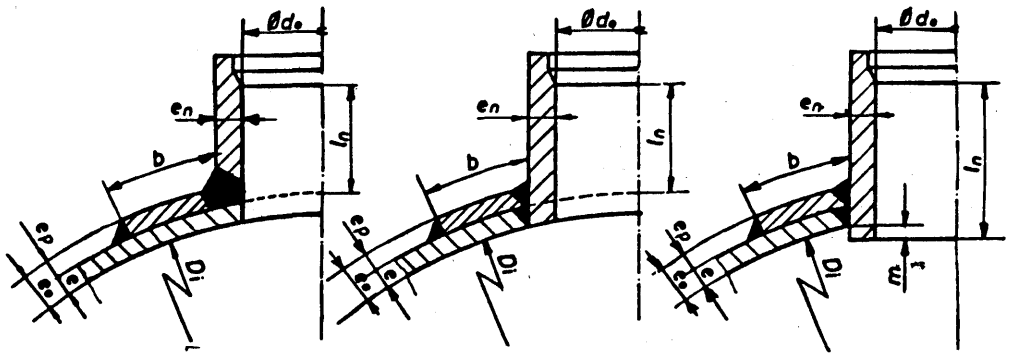


Figure I.13

Type V: by a welded nozzle and a stiffening ring



The weakening factor Z_o is given in Figure I.14 for cylindrical parts and Figure I.15 for spherical parts as a function of the ratio:

$$\frac{d_o}{\sqrt{(D_i + e_o)\, e_o}} \text{ and for different values of } \frac{e_n}{e_o}$$

taking account of the following restrictions:

— *For type I:* the lowest curves are applicable

$\left(\frac{e_n}{e_o} = 0\right)$

Factor Z_o for cylindrical shell rings

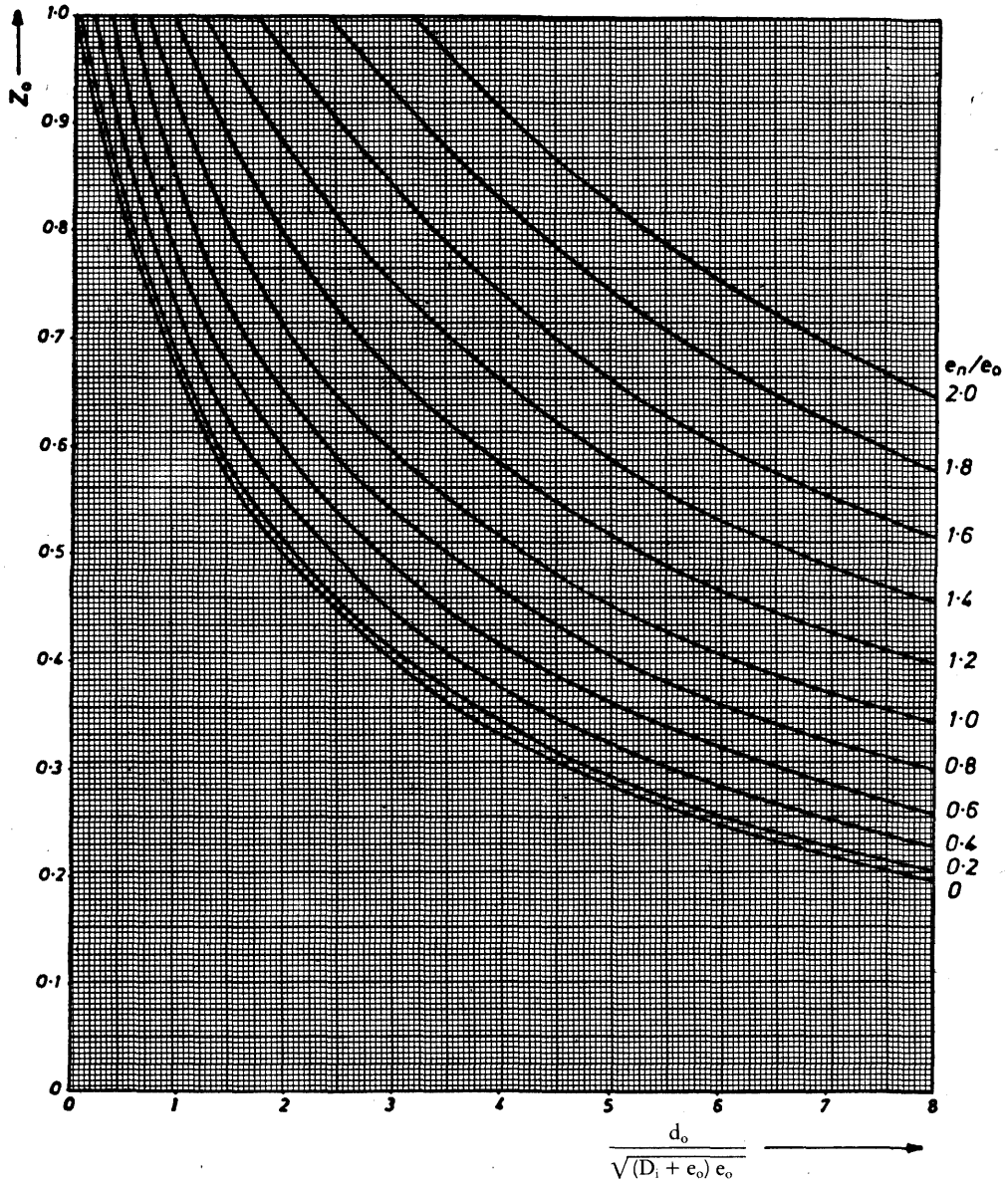


Figure I.14

Factor Z_o for spherical parts

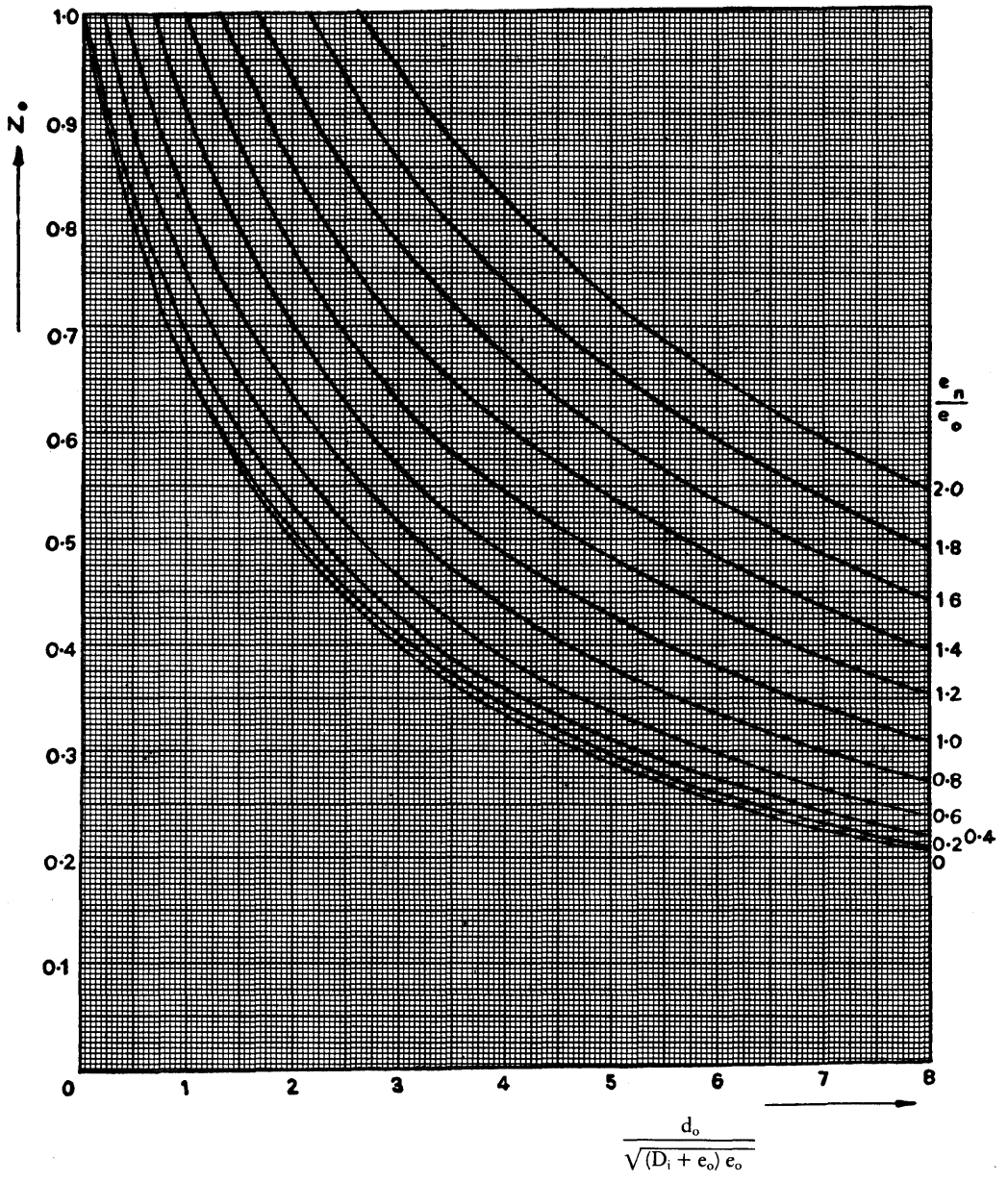


Figure I.15

— *For type II:*

the lowest curves are applicable

$\left(\frac{e_n}{e_o} = 0\right)$ and : $3e_o \leqslant b = \sqrt{(D_i + e_o)\, e_o}$

$e_p \leqslant e$

the width b may be reduced to b_1 provided that the thickness of the stiffening ring e_p is increased to e_{p1} in accordance with

$b_1 e_{p1} \geqslant b\, e_p$ with $b_1 \geqslant 3e_o$ and $e_{p1} \leqslant e$

— *For type III:*

$\frac{e_n}{e_o} \leqslant 2$ and $l_n = \sqrt{d_o \cdot e_n}$

the height l_n may be reduced to l_{n1} provided that the branch thickness e_n is increased to e_{n1} in accordance with:

$l_{n1} \cdot e_{n1} \geqslant l_n \cdot e_n$ with $\frac{e_{n1}}{e_o} \leqslant 2$

for a protruding branch, the thickness of the branch e_n may be reduced by 20 % provided that the protrusion m is not less than e_n.

— *For type IV:*

the length $l_n = \sqrt{d_o \cdot e_n}$

— *For type V:*

the restrictions listed for types II and II are applicable.

I.5. Access and inspection apertures

I.5.1. All vessels must be provided with manholes and/or inspection apertures located so that the vessel may be examined visually.

The minimum number and type of apertures in the cylindrical part of a vessel are given in Table I.2.

TABLE I.2

Number and type of apertures

Inside diameter (D_i)	Length of cylindrical section (L)	Minimum number				
		Small sight hole	Large sight hole	Hand hole	Head hole	Man hole
$0 < D_i \leqslant 300$		2 notes 1 and 2	0	0	0	0
$300 < D_i \leqslant 450$		0	2 notes 1 and 2	0	0	0
$450 < D_i \leqslant 800$	0 L ⩽ 1 500	0	2 or 1 note 2	note 3	0	0
	1 500 L ⩽ 2 000	0	0	2 or 1 note 3	note 3	0
	L > 2 000	0	0	note 4		0
$800 < D_i \leqslant 1\,500$	0 L ⩽ 2 000	0	0	note 3	1 note 3	0
	L > 2 000	0	0	note 4		0
$D_i > 1\,500$		0	0	0	0	1

Note 1: where the length exceeds 1 500 mm, additional sight holes must be provided.

Note 2: the sight holes must be located near the ends (providing a view of the longitudinal weld).

Note 3: a single head hole and a single hand hole which must be situated in the central third of the vessel length.

Note 4: the number of inspection holes must be increased accordingly. For a length of less than 3 000 mm, however, it is sufficient to site a head hole in the centre of the cylindrical section. On the cylindrical section, the distance between two head holes must not exceed 3 000 mm and the distance between two hand holes 2 000 mm. The latter must each be situated near an end.

I.5.2. Dimensions of apertures

I.5.2.1. Sight holes are apertures with an inside diameter of at least 30 mm (small sight holes) or 50 mm (large sight holes). The flange height must not exceed the diameter of the aperture.

I.5.2.2. Hand holes are apertures through which the hand and a lamp can be inserted. A hand hole must have an elliptical opening of at least 80 × 100 mm or an inside diameter of 100 mm.

The flange height must not exceed 65 mm or, if conical in shape, 100 mm. If only one hand hole is provided, it must not be less than 100 × 120 mm or 120 mm inside diameter.

I.5.2.3. Head holes are apertures through which the head, an arm and a lamp can be introduced simultaneously. Their dimensions must be at least 220 × 320 mm or 320 mm inside diameter; the flange height must not exceed 100 mm.

I.5.2.4. Man holes are apertures which a person not carrying any auxiliary equipment can enter and leave the vessel. They must not be less than 300 × 400 mm inside diameter. The flange height must not exceed 150 mm or, if conical in shape, 170 mm.

I.5.3. Remarks

I.5.3.1. If for design reasons the maximum flange height given above has been exceeded, the openings must be enlarged accordingly so as to give the same facilities for internal inspection of the vessel.

I.5.3.2. The conditions set out in the tables are applicable subject to the provisions of section 1 of the Annex.

I.6. Flanges

Flanges must comply with a national standard and may be used only for the pressure specified in that standard.

ANNEX II

DESCRIPTION OF TESTS

II.1. **Mechanical tests**

II.1.1. The following tests shall be performed in accordance with the Euronorms specified:

— Tensile test

Euronorm No 2-57 for e ⩾ 3 mm,
11-55 for e < 3 mm.

— Bend test

Euronorm No 6-55 for e ⩾ 3 mm,
12-55 for e < 3 mm.

— Impact test

Euronorm No 45-63.

— Hardness test

Euronorm No 3-55.

II.1.2. Acceptance criteria

II.1.2.1. Tensile test in welds and parent materials

The breaking load obtained must be at least equal to the minimum breaking load specified for the plate.

II.1.2.2. Bend test on welds

Each test piece is placed on supporting roller so that the mandrel axis is in the centre of the weld; the test piece must pass between the supports under the action of the mandrel. The diameter of the mandrel and the space between the supporting rollers shall be determined as follows depending on the thickness of the test piece 'e':

Table for bend tests

Minimum breaking load specified for the plate	Diameter of mandrel	Space between supporting rollers at the end of test
Less than 440 N/mm²	2 e	4·2 e
From 440 to 500 N/mm²	3 e	5·2 e

After the test the outside surface of the test piece shall not exhibit any cracks or other defects of a length exceeding 1·5 mm measured transversely to the test piece or 3 mm measured in the longitudinal direction of the test piece. A premature rupture at the corners of the test piece is not regarded as a reason for rejection.

II.1.2.3. Impact test on welds

Three test pieces are required. The impact test are carried out under the conditions set out in the third indent of 12.1 in the Technical Annex.

The results are acceptable if the mean value is not less than 35 J/cm² and if at the same time the lowest value is not less than 25 J/cm².

II.1.2.4. Hardness test on welds

The maximum Vickers hardness of the weld metal and the metal in the heat-affected zone may not exceed that of the parent metal by more than 80 and 100 units respectively.

II.2. Non-destructive examination

II.2.1. Radiographic examination

II.2.1.1. Preparation

If need be, scores and irregularities on the two faces of the weld may be removed or rectified by an appropriate mechanical process so that the radiographic image of these irregularities cannot conceal or be confused with the image of a defect to be detected. If so specified, the reinforcement on each bead must be reduced to 2 mm.

II.2.1.2. Procedure

Welds must be radiographed in accordance with ISO specifications R 1166 or R 1167 using classifications B or C or the techniques recommended in ISO 2405.

II.2.1.2. Identification of radiographs

Reference marks must be placed along the weld so as to identify each radiograph according to its location.

Lead characters must be placed along the weld to give the following information on each radiograph:

1. the area of the weld bead convered by the radiograph;
2. the location of the weld bead using appropriate letters for the various beads with a number showing whether this bead is the first, second, third, etc.;
3. a serial number denoting the specific vessel to which the radiograph relates;
4. marking of weld repairs on the section of the welded connections shown in the radiograph.

II.2.1.4. Image quality indicator (IQI)

The image quality indicator must comply with the requirements of ISO recommendation R 1027 'Radiographic image quality indicators — principles and identification'. If a wire-type indicator is used, the smallest wire diameter visible must not exceed the values given below.

If the step-and-hole indicator is used, the diameter of the smallest visible hole must not exceed the values given below.

Thickness of plate in mm	Wire-type indicator	Step-and-hole indicator
$e \leqslant 6$	0·10	0·25
$6 < e \leqslant 8$	0·125	0·32
$8 < e \leqslant 10$	0·16	0·40
$10 < e \leqslant 16$	0·20	0·50

II.2.1.5. Examination of radiographs

Weld radiographs should be examined on the original films in accordance with the procedure recommended in ISO standard 2504.

II.2.1.6. Interpretation of results

The following defects are not acceptable:

— any cracks or areas showing a lack of fusion at the weld root,

— any elongated inclusion which is greater in length than the thickness 'e' of the plate and at least equal in width to the smaller of the following two values: 2 mm or half the thickness 'e', where 'e' is the thickness of the materials adjacent to the weld. If the weld consists of two different thicknesses, the larger is considered,

— any porosities greater than those shown in the charts in Figures II.1, II.2 and II.3.

Porosity charts for thicknesses of less than 6 mm

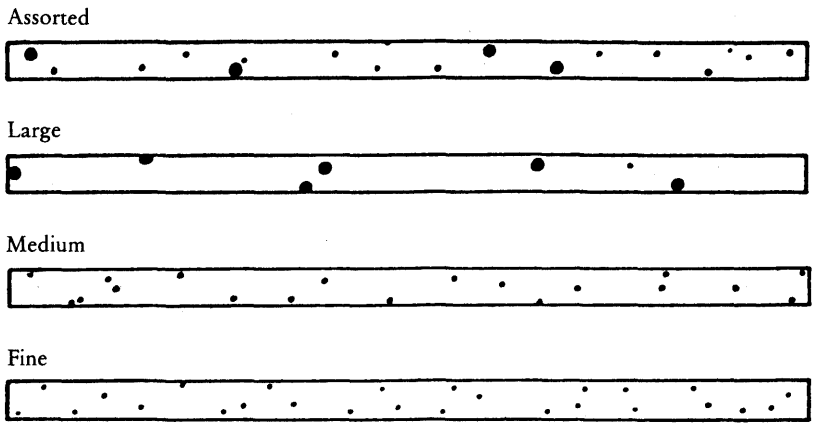


Figure II.1

Porosity charts for thicknesses of 6 to 13 mm

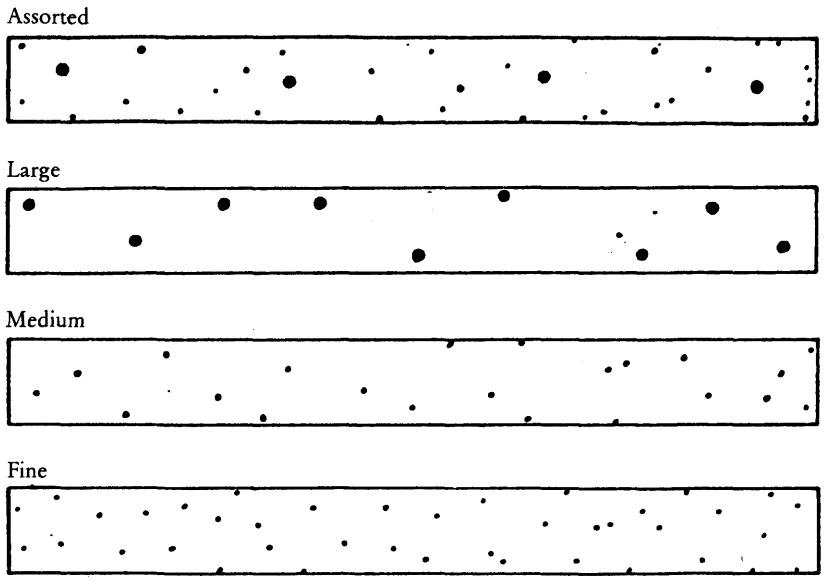


Figure II.2

Porosity charts for thicknesses exceeding 13 mm

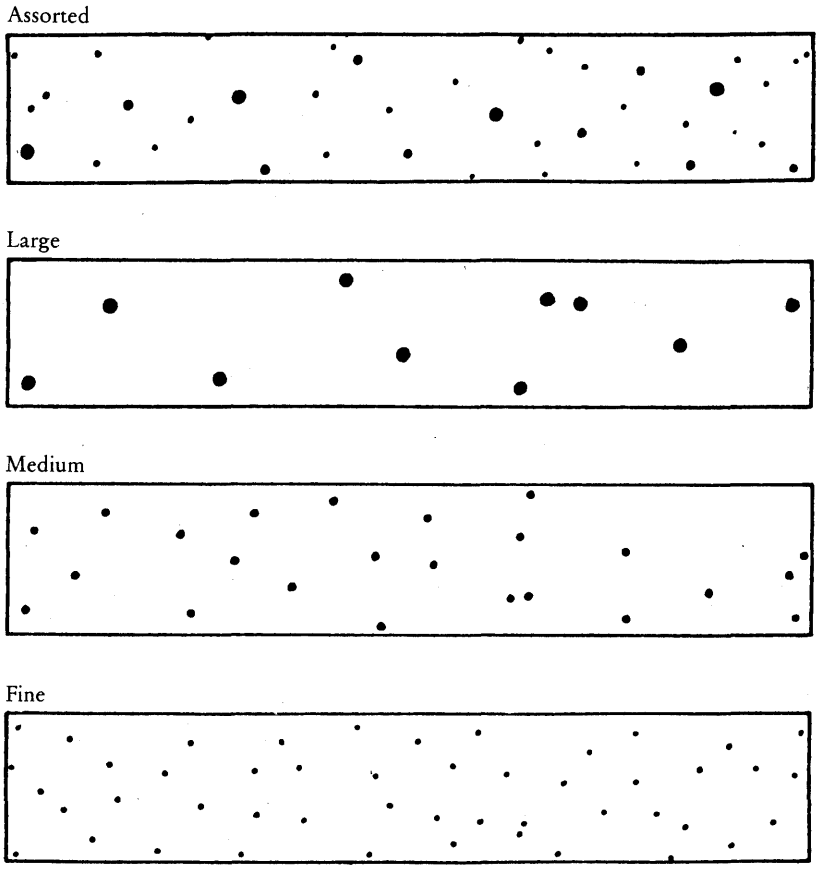


Figure II.3

II.2.3. Macrographic examination

The macrographic examination of a complete weld cross-section must reveal good penetration and an absence of any fusion defects, significant inclusion or other defects.

In cases of doubt, a micrographic examination of the doubtful zone must be carried out.

II.2.4. Penetrant fluid weld test

This shall be carried out in accordance with the specifications of ISO document DIS 2694 Annex J.

II.2.5. Ultrasonic test

II.2.5.1. Techniques

The examination shall be carried out in accordance with the specifications in ISO document DIS 2694.

II.2.5.2. Unacceptable weld defects

The limits on linear defects specified in the first two indents of II.2.1.6 may be regarded as valid for tests by magnetization and penetrant fluid tests. When the interpretation of the defects reveals cracks, incomplete fusion or incomplete penetration, these defects shall be regarded as unacceptable whatever their length.

II.3. **Overall tests**

II.3.1. Pressure cycling test

For this purpose, a hydraulic test is performed in cycles in which the pressure is repeatedly built up from the initial or residual pressure to the test pressure.

The test parameters must comply with one of the following sets of conditions, the choice being left to the Member State concerned:

1. — total number of cycles: 80 000,
   — test pressure: $^2/_3$ Ph + residual pressure,
   — frequency: 15 cycles per minute.
2. — total number of cycles: 15 000,
   — test pressure: Ph + residual pressure,
   — frequency: 5 cycles per minute.

The residual pressure (i.e. the pressure remaining after the vessel decompression phase) must not exceed 5 % of the test pressure.

Throughout the test, the temperature measured on the outside wall of the vessel must not exceed 50 °C.

The test is regarded as satisfactory if the vessel completes the specified number of cycles without leaking.

II.3.2. Hydrostatic test

Every vessel must undergo a hydrostatic test at a pressure Ph which must not be less than the value given by the equation set out below:

$$P_h = 1{\cdot}4\, P \frac{R_E}{R_{ET}}$$

R_E is the guaranteed minimum yield point at the test temperature;

R_{ET} is the yield point at the working temperature;

P is the working pressure.

However, the pressure P_h must be such that it does not create in the vessel a general membrane stress greater than 90 % of the minimum value of R_E.

The test pressure must be held at the specified value long enough to allow all the surfaces and joints to be examined visually. The vessel must not show any sign of general plastic deformation or leakage.

Every vessel tested which fails the hydrostatic test must be rejected.

II.4. **Destructive testing**

II.4.1. Hydraulic pressure bursting test

II.4.1.1. Procedure

The hydraulic pressure bursting test must be performed in two successive stages using an installation enabling the pressure to be built up regularly until the vessel bursts and a graph showing the variation of pressure with time to be recorded.

In the initial stage, the rate of pressure build-up to the value corresponding to the onset of plastic deformation must be equal to about five bar.

With the test, it must be possible to determine:

(a) the pressure at which plastic deformation commences;

(b) the bursting pressure;

(c) local and overall deformation of the vessel.

II.4.1.2. Test acceptance criteria

The measured bursting pressure (P_r) must be higher than the calculated theoretical minimum bursting pressure (P_{rt}).

This theoretical pressure is calculated from the minimum thickness obtained by applying the formula set out in Annex I and from the vessel's calculated minimum guaranteed tensile strength (R_R) according to the formula:

$$P_{rt} = \frac{20_e \cdot R_R}{D - e}$$

ANNEX III

COUPON PLATE

Quality control is carried out on one or more coupon plates.

To represent the longitudinal joint, the coupon plate shall consist of an extension piece added to the joint in question and welded at the same time. Furthermore the parent material and thickness of the coupon plate shall be identical with those of the shell ring.

No coupon plate need be provided for circumferential joints if the welding procedure and technique are the same for both types of joint.

If the method of welding circumferential joints differs from that used for longitudinal seams, a separate coupon plate must be prepared by the same welding procedure as used for the circumferential welds on the vessel. This coupon plate shall consist of two sections of tube of the same material, thickness and diameter as for production, welded together by a circumferential weld.

The dimensions of the coupon plate shall be such that a sufficient number of test pieces can be taken to carry out the tests specified in section 12.

ANNEX IV

ACCEPTANCE OF THE WELDING PROCEDURE

IV.1. **General**

By having the welding procedure accepted, the manufacturer must prove that he is capable of welding materials to be used for the construction of the pressure vessels to be produced.

For that purpose he shall carry out test welds in accordance with the following specifications.

The test welds shall consist of the execution of butt welds and fillet welds. These welds must be representative of the production welds on all parts subjected to pressure in the vessels.

IV.2. **Execution of the welds**

IV.2.1. Parent metal

The plates and tubes used for the welding procedure acceptance tests shall be of the same grade and shall conform to the same specifications as the plates and tubes used in actual production. However, acceptance for a given grade is also valid for grades having a lower impact strength and less favourable chemical composition.

IV.2.2. Filler products

The weld filler materials, i.e. electrodes and combinations of wire, powder and shielding gas, must be the same for acceptance of the welding procedure as for actual production.

IV.2.3. Type of edge preparation

In manual welding, the type of preparation (single or double V, single or double U and straight bevel) may be changed in production welding without necessitating reacceptance of the welding procedure.

In the case of semi-automatic welding, any change in the type of edge preparation requires a fresh acceptance test.

IV.2.4. Welding method

The welding method and, in the case of semi-automatic or automatic welding, the type of welding equipment must be the same for the acceptance test as for actual production.

IV.2.5. Validity of the welding procedure

IV.2.5.1. A fresh acceptance test is required if:

(a) in arc welding, the current range and welding speed and, in submerged arc welding, the range of voltages used are appreciably modified;

(b) in the arc welding of a simple butt joint, the back support is added or removed;

(c) in the oxyacetylene welding of a simple butt joint, a back support is added;

(d) in the case of machine welding, multi-pass welding on each face is replaced by one-pass welding on each face;

(e) if the shielding gas is changed or not used.

IV.2.5.2. Longitudinal and circumferential joints

If a test plate is welded to represent longitudinal joints, there is no need for a test on the circumferential joints provided that the welding method, procedure and techniques are the same for the two types of joint.

If the method of welding circumferential joints differs from that used for longitudinal joints, a test piece consisting of two tubular sections assembled by means of a circumferential weld must be produced in accordance with the procedure used for the circumferential welds on the vessel.

IV.2.6. Dimensions of the test assembly

The dimensions of the test assembly shall be such that it is possible to take a sufficient number of test pieces to carry out the tests specified in 2.7 of Annex IV.

IV.2.7. Inspection and testing

IV.2.7.1. Butt welds

The tensile, bend, impact and hardness tests shall be carried out in accordance with the specifications in II.1.1 of Annex II.

The inspections and tests to be carried out are as follows:

(a) a radiographic examination

the radiographic examination shall be carried out on the full length of the welds and before test pieces are taken;

(b) one tensile test

the tensile test piece shall be cut transversely to the weld;

(c) three impact tests in the weld;

(d) one bend test on the underside of the weld;

(e) one bend test on the upper side of the weld;

(f) a macrographic examination;

(g) one hardness test.

IV.2.7.2. Fillet welds

The examinations to be carried out are as follows:

(a) a visual examination;

(b) a macrographic examination.

IV.2.8. Acceptance criteria

IV.2.8.1. The acceptance criteria for the tensile, bend, impact and hardness tests are specified in II.1.2 of Annex II.

IV.2.8.1.1. The radiographic examination shall be carried out in accordance with II.2.1 of Annex II:

IV.2.8.1.2. The macrographic examination shall be carried out in accordance with II.2.3 of Annex II.

ANNEX V

QUALIFYING TESTS FOR WELDERS OR OPERATORS

The qualifying tests for welders or operators shall be carried out in exactly the same way and under the same conditions as the welding procedure acceptance tests.

The requirements for the qualifying tests for welders or operators are the same as for the welding procedure acceptance tests.

Welders or operators must undergo fresh qualifying tests if the welding procedure has to be re-accepted as a result of a change in one of the conditions specified in 2.5 of Annex IV.

Welders or operators must qualify if they have not been engaged on the same type of work in the construction of pressure vessels during the previous six months.

ANNEX VI

EEC PATTERN APPROVAL CERTIFICATE

issued pursuant to Council Directives 76/767/EEC of 27 June 1976 and . . . of . . .

Pressure vessels

Approval No:	Date:
Type of vessel:	'Description of the vessel or variant approved'
	Capacity: L: thickness:
	Pmax: D:
Manufacturer or agent:	'Name and address of the manufacturer or his authorized agent'
EEC pattern approval mark:	Article 3 (a)  4 F 8453
	Article 3 (b)  4 F 8453
Validity:	5 years/10 years
Any further information may be obtained from:	Name and address of the inspection authority

Done at _____, (date) _____

_____

(Signature)