HSE APPROVED SPECIFICATION

SPECIFICATION FKCO 1120 (HSE)

WELDED GAS CONTAINERS FROM 450 T0 1000 L CAPACITY MANUFACTURED FROM FINE GRAIN STEEL

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1. Scope

1.1. Permitted gases

Permanent and liquefied gases for test-pressures between 35 and 120 bar.

1.2. Filling pressure at 15ºC (Permanent Gases)

55 bar maximum.

1.3. Nominal water capacity

450 litres to 1000 litres inclusive.

1.4. Material of construction

One specified analysis of weldable fine grain carbon steel only.

1.5. Design Temperature

The design temperature shall be -20ºC to 50ºC, or -40ºC to 50ºC depending on the requirements specified by the customer.

1.6. Drawing

A fully dimensioned drawing shall be produced.

2. NORMATIVE REFERENCES

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

EURONORM 120 -83 Sheet steel and strip for gas cylinders

EN 287-1 Approval testing of welder; Fusion welding; Part 1: Steels

EN 288-1 Specification and qualification of welding procedures for metallic materials; Part 1: General rules for fusion welding

EN 288-3 Specification and approval of welding procedures for metallic materials; Part 3: Welding procedure tests for the arc welding of steels

EN 962 Valve caps and guards

EN 10 002-1 Metallic materials; Tensile testing; Part 1: Method of testing (at ambient temperature)

EN 1089-1 Stamp marking of gas cylinders.

prEN 895 Welding - Welded butt joints in metallic materials - transverse tensile test

prEN 910 Welding - Welded butt joints in metallic materials - bend tests

prEN 10120 Steel Sheet and strip for welded gas cylinders

prEN 1435 Recommended practice for radiographic examinations of fusion welded joints.

prEN 150-11114-1 Compatibility of cylinder and valve materials with gas contents- Part 1- Metallic materials

EN 10045-1 Test method (V and U notches)

EN 970 Welding - Visual examination of fusion welded joints

BS 5355 Filling ratios and developed pressures for liquifiable and permanent gases.

3 DEFINITIONS

For the purpose of this standard, the following definitions apply:

3.1. Yield Stress

See EN 10 002-1.

By "yield stress" is meant the stress at which a permanent elongation of 2 per thousand (i.e. 0.2%) or, for austenitic steels, 1% of the gauge length on the test-piece has been produced.

NOTE: In the case of sheet-metal the axis of the tensile test-piece shall be at right angles to the direction of rolling. The permanent elongation at fracture, (l=5d) shall be measured on a test-piece of circular cross-section in which the gauge length, (l) is equal to five times the diameter, (d) if test pieces of rectangular cross-section are used, the gauge length,(l) shall be calculated by the formula:

$$l = 5.65 \sqrt{S_o}$$

where S_O indicates the initial cross-sectional area of the test-piece.

3.2 Normalising

Heat treatment in which a finished cylinder is heated to a uniform temperature above the upper critical point (AC_3) of the steel and then cooled in a controlled atmosphere.

3.3. Stress relieving

Heat treatment given to the finished cylinder, the object of which is to reduce the residual stresses without altering the metallurgical structure of the steel.

3.4. Batch

A batch shall consist of finished cylinders made consecutively during the same or consecutive days to the same design, size and material specifications and from the same material supplier on the same automatic welding machines and heat-treated under the same conditions of temperature and duration.

3.5. Filling Ratio

The filling ratio is the mass of gas in kg which can be filled into 1 litre of drum water capacity.

3.6. Filling Ratio Reference Temperature

The filling ratio reference temperature stated in BS 5355 at which the liquid density is to be evaluated for calculating the fill ratio.

3.7. Developed Pressure

The developed pressure is the pressure achieved by the contents of a pressure drum filled according to BS 5355 when raised to the reference temperature for developed pressure.

3.8. Developed Pressure Reference Temperature

The developed pressure reference temperature is the temperature at which the developed pressure is to be determined.

3.9. Settled Filling Pressure

The settled filling pressure is the pressure (permanent gases) of the contents of the drum at 15ºC.

4. CERTIFICATE OF COMPLIANCE

The verification body shall certify that manufacture, inspection and testing of the cylinders was carried out in compliance with the requirements of this specification.

Note: A suitable form of certificates are shown in appendix I A, B, C and D.

5. MATERIALS OF CONSTRUCTION

5.1. General

5.1.1. The material used for gas cylinder manufacture shall be compatible with the intended gas service e.g. corrosive gases, embrittling gases. Reference - prEN ISO 11114-1. Transportable Gas Cylinders - Compatibility of Cylinders and Valve Materials with Gas Contents - Part 1. Metallic Materials.

5.1.2. All parts welded to the cylinder shall be made of compatible material with respect to the weldability.

5.1.3. The welding consumables shall be such that they are capable of giving consistent welds with minimum tensile strength at least equal to that specified for the parent material in the finished cylinder.

5.1.4.. The cylinder manufacturer shall obtain and provide certificates of the ladle analysis of the steel supplied for the construction of the pressure retaining parts of the cylinder.

5.1.5. The manufacturer shall be able to identify any cylinder with the cast of steel from which it is made.

5.2. Heat treatment

Cylinders shall be delivered in either the normalised or the stress-relieved condition (see 3.2 and 3.3). The cylinder manufacturer shall certify that the cylinders have been heat-treated after completion of all welding and shall certify the process of heat treatment applied.

Localised heat treatment is not permitted.

5.3. Test requirements

The material of the finished cylinders shall satisfy the requirements of clauses **8 and 9.**

5.3.1. Failure to meet test requirements. In the event of failure to meet test requirements, retesting or reheat treatment and retesting shall be carried out as follow:

5.3.2. If there is evidence of a fault in carrying out a test, or an error of measurement a further test shall be performed. If the result of this test is satisfactory, the first test shall be ignored.

5.3.3. If the test has been carried out in a satisfactory manner, the cause of test failure shall be identified.

If the failure is considered to be due to the heat treatment applied, the manufacturer may subject all the cylinders of the batch to a further heat treatment.

If the failure is not due to the heat treatment applied, all the identified defective cylinders shall be rejected or repaired. The remaining cylinders are then considered as a new batch.

In both cases the new batch shall be inspected and tested. All the relevant prototype or batch tests needed to prove the acceptability of the new batch shall be performed again. If one or more tests prove even partially unsatisfactory, all the cylinders of the batch shall be rejected.

5.3.4. Reheat treatment

The conditions for the reheat treatment shall be the same as for the first heat treatment, e.g. normalised cylinders shall be renormalised.

5.4. Permissible steelmaking process.

Electric and furnace or oxygen process with refinement of structure. The steel shall be fine grained and contain sufficient additions for the fixation of nitrogen.
The steel shall be supplied in the normalised condition.

EN 10028-3 to apply. Steel grade P355N or P355NLI to be used depending on the specified minimum operating temperature.

Steel analysis is given in table 1.

Table 1: Steel chemical composition

Grade P355N shown below
Variations for grade P355NL1 shown in brackets.

	% content by weight	
Element	**minimum**	**maximum**
Carbon		0,20 (0,18)
Silicon		0,50
Manganese	0,90	1,70
Phosphorus		0,030
Sulphur		0,025(0,020)
Aluminium	0,020	
Chromium		0,30
Copper		0,30
Molybdenum		0,08
Nitrogen		0,02
Niob		0,05
Nickel		0,50
Titanium		0,03
Vanadium		0,10
Nb + Ti + V	= max	0,12
Cr + Cu + Mo	= max	0,45

Their permissible deviation on product analysis from specified range as per EN 10028-3 - table 2.

Steel maker shall supply a certificate to EN 10204 stating:

a. the steelmaking process;

b. the ladle analysis;

c. mechanical test results on heat treated samples.

These certificates shall be retained by the manufacturer of the cylinders.

5.5. Mechanical properties

The following shall be obtained:

tensile strength:	N/mm^2	490 minimum - 630 maximum
yield strength:	N/mm^2	355 minimum - 420 maximum
elongation on 5,65 s:		22%
radius of bend test former:		4 x ta maximum (where ta = actual thickness)

5.6. Charpy-v notch impact values.

The impact test on V -notched test pieces shall be carried out as described in EN 10045-1

The minimum impact values on longitudinal test pieces apply to the average of 3 test pieces. One individual value may be lower than the specified value provided that it is not less than 70% of this value.

Grade P355N - 40 J/cm^2 at minus 20^oC
Grade P355NL1 - 34 J/cm^2 at minus 40^oC

6. CYLINDER DESIGN

6.1. General requirements

6.1.1. Cylinder

Permissible designs according to this specification are restricted to cylinders having concave to pressure dished ends, hot pressed-upper dished ends having an opening with block flange welded into the dished end, covered by a flange lid bolted to the block flange. Two triangular flanges being bolted to the flange lid to accept valves, each valve flange having dip tubes welded to the valve flange. Alternatively taper threaded valves in accordance with prEN 849, BS 341 Part 1 or other recognised standard, shall be fitted to a tapered tapping in a boss welded to the drum , or to a flange bolted to a block flange.

6.1.2. Valve fittings

Valve fittings shall comply with the requirements of prEN 849, BS 341 : Part 1, BS1319 or other recognised standard as appropriate, in respect of quality and materials.

6.1.3. Valve protection

Means for attaching valve protection shall be provided on all cylinders

Such means shall not involve welding, brazing or soldering any fitting whatsoever to the cylinder.

6.2. Nomenclature

t = minimum cylinder wall thickness (mm) - to resist internal pressure and external forces due to normal handling, but excluding additional thickness for corrosion and other influences.

t_e = is the minimum thickness of ends (mm) to resist internal pressure and external forces due to handling, but excluding any additional thickness for corrosion and other influences.

D_o = external diameter of cylinder (mm)

D_i = internal diameter of cylinder (mm)

P_1 = test pressure (bar)

P = pressure (bar) developed by gaseous contents at reference temperature (Design Pressure)

P_f = settled filling pressure at 15ºC (bar)

K = is the shape factor obtained according to the values h_e/D_o and t_e/D_o. See figure 1.

s = safety coefficient

V = welded joints efficiency

c = additional wall thickness equal to the tolerated minus deviation for the steel plates. (mm)

c_r = additional wall thickness for corrosion allowance (mm)

f = maximum permissible equivalent stress (N/mm^2) at test pressure

Y = minimum specified yield stress (N/mm^2)

T = minimum specified tensile strength (N/mm^2)

6.3. Maximum developed service pressure (p)

The maximum developed pressure in service (p) shall:-

a) Not exceed 65% of the test pressure P_1 for permanent gases;

b) Not exceed the test pressure P_1 at the reference temperature and fill ratio listed in BS 5355 for liquefiable gases.

6.3.1 Settled Filling Pressure and Fill Ratio

The settled filling pressure (permanent gases) and fill ratio (liquifiable gases) at 15ºC shall comply with BS 5355 such that the developed pressure at the reference temperature shall not exceed the value P.

6.4. Test pressure ($P_{1)}$

The test pressure P_1 shall be the design pressure P.

6.4. Test pressure ($P_{1)}$

The test pressure P_1 shall be the design pressure P.

6.5. Mechanical properties for design

The mechanical properties of the cylinder used for design (and guaranteed by the manufacturer as minimum values) shall be:

Y = 355 N/mm^2

T = 490 N/mm^2 the corresponding ratio Y/T is 0,72

6.6. Design stress at test pressure

The design stress at test pressure shall be: f = 0,75 Y x V

V *for 100 % radiography = 0.95*

6.7. Thickness of cylindrical shell

Thickness 't' shall not be less than that from formula (1)

$$t = \frac{0.3P_1D_i}{7f_e - P_1} + c + c_r \text{ or } t = \frac{0.3P_1D_o}{7f_e - 0.4P_1} + c + c_r \qquad (1)$$

except that the thickness of the cylindrical wall determined by equation (1) shall not be less than the value given by equation (2):

$$t = 2.48\sqrt{\left(\frac{D_i}{T}\right)} \qquad (2)$$

6.8. Thickness of dished ends.

6.8.1. Design on ends concave to pressure

When the material of the ends is the same as that used for the cylindrical part of the shell, the wall thickness of the domed ends shall be the greater of:-

(i) the thickness of the cylinder wall; or
(ii) the value calculated from the equation $t_e = tK$

6.8.2. Limitation of shape

In a semi-ellipsoidal end the ratio h_o/D_o shall be not less than 0.192.

7. APPROVAL OF DESIGN AND CONSTRUCTION

Before manufacture commences, three copies of detailed design drawings, together with design calculations in accordance with section 6 of this specification, and a statement on the method of manufacture (see section 8)**,** shall be submitted to the Approved Verification Body for approval. Design drawings shall carry an unique identifying number.

No alteration shall be made to the design or method of manufacture after approval, unless such alteration has received prior agreement of the Approved Verification Body.

8. CYLINDER MANUFACTURING PROCESS

8.1.. Welding procedures

Each manufacturer, before proceeding with the production of a given design of cylinder, shall qualify the welding procedures and welders to EN 288 and En 287. Records of such qualification shall be kept on file by the manufacturer.

a) Procedure qualification tests shall be performed in such a manner that the welds shall be representative of those made in production.

b) Welders shall have passed the qualification tests for the specific type of work and procedure concerned.

c) Re-qualifying of the procedure, as well as the welder, shall be required if there is change in any of the essential variables as detailed in the Qualification Standard.

8.2. **Welded joints**

8.2.1 The welding of the longitudinal and circumferential seams including the boss-weld shall be by an automatic process.

8.2.2 The longitudinal joint, of which there shall be no more than one, shall be butt-welded. fittings

8.3. Non-pressure-containing attachments

8.3.1 Neckrings, footrings, handles, bosses, pads and rings not subject to pressure of the contents may be attached to the cylinder by welding, provided that such attachments are made of weldable and compatible steel.

8.3.2 Each attachment shall be designed to permit inspection of the welds, which shall be clear of longitudinal and circumferential joints, and so designed as to avoid trapping water.

8.3.3 A footring of adequate strength shall be fitted when applicable to the cylinder to provide stability, and welded so as to permit inspection of the bottom circumferential weld. The footring shall be suitably drained and the space enclosed by the footring suitably ventilated.

8.3.4. One strengthening (rolling ring) may being welded to the head and bottom shrouds each. No rings welded to any pressure bearing part of the cylinder.

8.4. Out of roundness

The out-of-roundness of the cylindrical shell shall be limited so that the difference between the maximum and the minimum outside diameter in the same cross-section is not more than 1% of the mean of these diameters for two piece cylinders and 1.5% for three piece cylinders.

8.5. Straightness

Unless otherwise shown on the drawing, the maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 0.3% of the cylindrical length.

8.3. Verticality

When the cylinder is standing on its base, the cylindrical shell and top valve openings shall be vertical to within 10mm per 1.0 metre length.

8.4. Heat Treatment

After welding the cylinders shall be stress relieved at a temperature 540 to 580 Centigrade. This temperature shall be maintain for a period of 30 minutes. Heating-up time and cooling-down time: 120 Centigrade per hour.

For hydrogen sulphide, the cylinders must be normalised after welding at 880º to 960ºC.

9. INSPECTION AND TESTS

9.1. General

The inspection and testing of the cylinders shall be carried out to the satisfaction of the Approved Verification Body, who shall certify that the cylinders comply with the requirement of this specification.

The purchaser and the Approved Verification Body shall have reasonable access to those parts of the works engaged on the order, for purposes of ensuring that the cylinders comply with the requirements of this specification.

Adequate notification of, and facilities for inspecting and testing shall be provided by the manufacturer to the Approved Verification Body.

9.1.1. Visual Inspection

Before assembly, the pressure parts of the vessel shall be visually examined, in accordance with EN 970, by the manufacturer for uniform quality and freedom from injurious defects.

Before the cylinder or vessel is closed, the longitudinal welds shall be visually examined by the manufacturer, from both sides.

All welds shall have an even finish without concavity and shall merge into the parent metal without undercutting or abrupt irregularity.
The manufacturer shall ensure that the welds show continuous penetration of the weld seams and that they are free of defects.

9.1.2. Non-destructive Testing

All welding seams to be X-Ray and ultrasonic tested:

9.1.2.1. Radiographic techniques

Radiographic examination shall be in accordance with EN 444

Radiographic sensitivity shall be determined in accordance with EN 462.

Defect assessment to AD-Merkblatt HP 5/3.

9.1.2.2. Ultrasonic Techniques

To AD Merkblatt HP 5/3 and DIN 54125

Before carrying out ultrasonic examination of the welds, the adjacent parent metal shall be ultrasonically examined to establish the thickness of the material and to locate any flaws which may prevent effective examination of the weld.

Defect assessment in accordance with Appendix II.

Before carrying out ultrasonic examination of the welds, the adjacent parent metal shall be ultrasonically examined to establish the thickness of the material and to locate any flaws which may prevent effective examination of the weld.

Defect assessment to Appendix II.
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9.2.Prototype tests

In addition to acceptance tests specified in clauses 9.5 and 9.6, the prototype tests specified in 9.2. to 9.4. are required on all new drum designs. These tests are to be approved by the Verification Body, or carried out by an independent test laboratory.

A drum shall be considered a new design if:

a. it is manufactured in a different factory;

b. the shape of the dished end is different (a convex to pressure dished end is not recommended);

c. an increase in hydraulic test pressure which does or does not require a change in wall thickness. (Where a drum is to be used as a lower pressure than that for which design approval has been given and prototype testing carried out successfully, it shall not be deemed a new design);

d. the inner diameter has changed by more than 5%.

e. if the charge pressure (permanent gases) or fill ratio (liquifiable gases) is increased, (with no increase in test pressure) resulting in an increase in the fatigue stress used for the assessment in section 9.4.2., only the assessment in 9.4.2. shall be repeated for the that design.

The cylinders used for tests shall be from the first production batch of the new design, and shall be certified by the manufacturer as being representative of the particular design and manufacturing process, including welding process and heat treatment (stress relieving or normalising). The prototype cylinder must not be painted but be in a virgin condition.

9.2.1. Hydraulic burst test

One cylinder of each new design shall be subjected to a hydraulic burst test. the rate of pressurisation shall not exceed 5 bar/second. In the course of the test, the yield pressure, burst pressure, burst mode and volumetric expansion shall be recorded.

The burst test shall fulfil the following acceptance criteria:

The yield pressure shall be equal to or greater than 4/3 times the design test pressures.

The burst pressure shall be equal to or greater than 2.0 times the design test pressure.

The cylinder shall burst from a point within the side wall in longitudinal direction.

The appearance of the fracture (rupture line) must be even and not show a brittle fracture status.

The cylinder shall remain in one piece after bursting.

9.3. Mechanical tests

9.3.1 General

The mechanical tests shall be carried out on the parent material and the welds.

Test specimens shall be cut from locations on the container as indicated in figure 2. Test specimens may alternatively be taken from a coupon plate, attached to the cylindrical part of the container, produced from the same materials and the same welding procedures and subject to the same heat treatment process, as the main seams. The specimen for tests on the parent material shall be cut so that no part of the gauge length of the test specimen is within 4t of the edge of the weld, where t is the minimum design thickness as specified on the drawing(s), see 1.6 (including any corrosion allowance).

The mechanical tests carried out on each container shall be in accordance with 9.3.2 to 9.3.6

A test specimen of each type required under 9.3.2 and 9.3.3 shall be cut from the cylindrical shell and from one of the end pressings.

Test specimens of each type required under 9.3.4 to 9.3.6 shall be cut transversely across the longitudinal weld and alternately from the top and bottom circumferential welds on successive containers selected for test.

9.3.2 Tensile test on parent material

The tensile test specimens T1 and T2 (see figure 2) shall be made from strips cut from a finished container with the axis of the strips, where possible, parallel to the axis of the container. Where necessary, test specimen T1 shall be cut transverse to the axis of the container as shown in figure 2. The form and dimensions shall be as specified in BS EN 10002. The face and back of the test specimen shall not be machined, but shall represent the surface of the container as manufactured.

The tolerance on form (i.e. the difference between maximum and minimum values of a given dimension in any one test specimen) for the machined surfaces of a test specimen shall be in accordance with the tolerance grade IT9 of BS 4500 : Part 1.

NOTE. The test specimens may be carefully straightened cold as necessary to place them in the testing machine

Tensile testing shall be carried out as specified in BS EN 10002. The limit of error of measurement shall be not more than +0.5% or 0.01 mm, whichever is the greater, as prescribed BS EN 10002 and shall be interpreted as applying to each individual measurement. If individual measurements of the thickness of a test specimen, the two faces of which are formed by the surfaces of the container wall, differ from one another, the minimum value shall be taken for calculation.

When the parallel length is in excess of the gauge length a series of overlapping gauge lengths shall be marked, or alternatively gauge marks be applied every 5 mm, 10 mm or 20 mm along the parallel length so that the elongation on the prescribed gauge length can be determined by some suitable method of interpolation.

The tensile testing machine shall be maintained to grade 1.0 of BS 1610: Part 1. The results obtained from the tensile test shall meet the minimum requirements of 5.5.

9.3.3 Bend test on parent material.

The width of the test specimens B1 and B2 (see figure 2) shall be not less than 25 mm or four times the minimum design thickness of the container as shown in the drawing(s), see 1.6, (including any corrosion allowance), whichever is the greater. The face and back of the test specimen shall not be machined except that the edges may be rounded off. When bent at room temperature round a former, of diameter not greater than n times the thickness of the specimen, until the gap between the ends is not greater than the diameter of the former, the specimen shall remain uncracked. Values of n are given in table 1.

9.3.4 Tensile test on the welds

The test specimens T3 and T4 (see figure 2) shall be cut transversely to the weld and shall be the full thickness of the material at the welded joint. The shape and dimension of the test specimen shall be as shown at figure 3.

In preparing the test specimens the face and back shall not be machined except to remove the backing strip or the tongue of a joggle joint. The face and back of the test piece shall each represent the surface of the parent material and the weld.

NOTE The test specimens may be carefully straightened cold as necessary in order to place them in the testing machine.

The tensile strength shall be not less than that specified for the parent material and where there are different parent materials joined by the weld it shall be not less than that specified for the parent material with the lowest tensile strength.

Tensile testing shall be carried out as specified in BS 18. The tolerance on form and limits of error measurement shall be described in 9.3.2. The tensile testing machine shall be maintained to grade 1.0 of BS 1610 : Part 1.

9.3.5 Bend test across the welds.

The width of the test specimen shall be 25 mm or four times the design thickness of the container, whichever is the greater. In preparing the test specimen the corners shall be rounded off and the backing strip or the tongue or a joggle joint and any weld reinforcement shall be machined off before testing.

$$t_{act} = \frac{P_{fat} D_i}{2f_f - P_{fat}}$$

Specimens B3 and B4 (see figure 2) shall be bent with the outer surface of the weld in tension, and specimens B5 and B6 (see figure 2) with the inner surface of the weld in tension.

When bent at room temperature round a former, of diameter not greater than n times the thickness of the specimen, until the gap between the ends is not greater than the diameter of the former, the specimen shall remain uncracked. Value of n is given in table 1. In a joggle joint welding configuration defects in the exposed end grain of the material shall not be sufficient reason for rejection, providing all other material tests are passed.

9.3.6 Nick- break tests on the welds

Two nick-break test specimens shall be made, the specimens NB1 and NB2 (see figure 2) being similar to those required for a bend test, except that a slot is cut along the weld on each side at the centre line. The slot shall be of a form shown in figure 4. The specimen shall then be broken cold in the weld by pressure or blows applied to one of the slotted faces, and the pressure shall reveal a sound, homogenous weld with complete penetration, free from oxide, slag inclusions or excessive porosity.

9.4. Prototype Fatigue Tests

9.4.1. Drum Test

One drum shall be taken from the first batch or production run made to a new design and submitted to the pressure cycling tests. the containers shall be certified by the manufacturer to be representative of his design and manufacturing procedure.

The containers shall be considered to have passed the test if they satisfactory complete, without any sign of leakage, either;
12000 cycles over a range equivalent to 0.9 x test pressure; or
80000 cycles over a range equivalent to 0.6 x test pressure.

9.4.2. Fracture Mechanics Assessment.

As an alternative to the prototype fatigue test, as specified in 9.4.1., a fracture mechanics assessment to PD 6493 may be made to illustrate that defect growth due to fatigue will not reduce the integrity of the drum. Once material properties have been found it should be demonstrated that the maximum allowable defect size will not grow to the Critical Crack Size in 100 000 cycles from atmospheric to the developed pressure at 35ºC.

Calculated values for the range of hoop stresses to be considered shall use the equation:

Where:

t_{act} = Drum actual thickness minus the corrosion allowance.

P_{fat} = Pressure for fatigue assessment. This is the developed pressure at 35ºC.

f_f = Stress for fatigue assessment.

9.5. Product sample test

This category comprises mechanical tests for steel as well as for welded seam. The test pieces shall be welded in elongation of the longitudinal seam. There shall be one test-piece per heat treatment batch. the rules laid down in AD-Merkblatt (sheet) HP 5/2 to be adhered to.

For sampling purposes a batch is defined as a group of containers of the same design, manufactured from the same cast of steel, having undergone the same heat treatment. One batch consisting of not more than 50 cylinders.

9.6. Hydraulic proof test

Every cylinder shall be subjected to a hydraulic test. The test pressure shall be determined by the requirements of Clause 4. No pressure greater than 65% of the test pressure shall have been applied to any cylinders before the test.

All rigid pipe work, flexible tubing valves, fittings and components shall be capable of withstanding a pressure twice the maximum test pressure of any cylinder to be tested.

Pressure gauges shall comply with the requirements of industrial class 1 of BS1780 : Part 2 or equivalent standards, they shall be tested at regular intervals, and in any case not less frequently than once a month.

The design and installation of the equipment and the cylinder connected to it shall be such as to avoid trapping air in the system.

The test pressure shall be established from the markings on the cylinder. When applied to the drum(s) it shall not exceed 3% or 10 bar, whichever is the lower.

On attaining the test pressure the drum(s) shall be isolated from the pump and the pressure held for a minimum period of 30 minutes, during which period the pressure as registered on the test gauge shall remain constant.

Under these conditions of test the drum(s) shall not show any sign of leakage, visible deformation of defect.

If there is a leakage in the pressure system it shall be corrected and the cylinder(s) retested.

The interior of each cylinder shall be thoroughly dried by a suitable method immediately after hydraulic testing. Cylinders shall not be heated above 80ºC.

9.7. Water capacity check

The water capacity of each cylinder shall be checked and recorded. This shall be done by weighing and by filling the cylinder with a calibrated column liquid, or by other means approved by the verification body, in order to ensure compliance with the required water capacity in the design drawing.

9.8. Visual inspection

Each cylinder shall have a final visual examination of welded joints, carried out in accordance with prEN 970.

If, in the judgement of the verification body a cylinder fails to meet the standards required by the specification, it shall be rectified or rejected.

9.9. Record of tests

A record shall be kept of all tests made at the drum manufacturers works.

10. Information to be marked

Each cylinder that complies with the requirements of this specification shall be permanently and legibly marked with the following information.

a. The manufacturers mark and drum serial number.

b. The test pressure (bar) and date of hydraulic test, indicated by the month and year and the identification mark of the person or company who conducted the test.

c. The identification mark(s) of the verification body.

d. The number of this specification, ie FKCO1120 (HSE).

e. The design water capacity of the drum as specified on the design drawing (1).

f. The weight of the drum, including permanent fittings only (Kg).

g. The settled filling pressure at 15ºC (bar) for permanent gases.

h. The fill ratio for liquifiable gases.

i. Identification of the product carried in accordance with The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996.

With the exception of item (c), (h) & (i), all of the above markings shall be made by the drum manufacturer.

Where a range of gases are to be carried, the fill ratio for each gas will be marked. This may be on a separate plate to the other information.

11. Position and size of marking

The manufacturers mark shall be on the head of the drum. No permanent marking shall be made on the body of the cylinder.

The marked characters shall normally be at least 10 mm high.

Item (i) shall be marked as required by the The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996.

APPENDIX 1A

Specimen Design Certificate for Welded Steel Gas Cylinders

Certificate No: . . . . . **Customer No:** . . . . . **Date**: . . . . . .

Manufacturer . . . . . **Specification** . . . . . .

Order No: **(Customer** . . . . . **(** **(Manufacturer** . . . . . .

Gas . . . . . .

Serial No(s): **(Customer** . . . . . **Quantity, ordered** . . . . . **(** **(Manufacturer** . . . . . .

Minimum specified yield stress . . . . . **Minimum specified tensile strength** . . . . .

Drawing	Test Pressure	Min Thickness		External Diameter	Nominal Length without cap or valve	Water Cap Nominal /Min*	Weight		
		Cyl,shell	Head				Min*	Max*	Nom*
		bar	mm	mm	mm	mm	L	Kg	Kg

*** Delete as appropriate**

Identification marks stamped on the cylinder Name Plate

a) **manufacturer's marks**
b) **the number of this Specification**
c) **filling pressure at 15°C**
d) **date of hydraulic test**
e) **Verification Body's mark (s)**
f) **test pressure**
g) **customer's mark(s) (if any)**
h) **cylinder serial number**
i) **weight of cylinder without valve**

APPENDIX 1B

Specimen Certificate for water capacity, weight and material

Water capacity and weight

Water capacity between . . . . . **and** . . . . . **L**

Weight between . . . . . **and** . . . . . **Kg**

Material

The cylinder in batch(es) . . . . . **were manufactured from the following cast(s) of steel:**

Steelmaker: . . . . . .

Cast	Steel	C	Si	Mn	P	S	Cr	Mo	Ni

APPENDIX 1C

Specimen Certificate for water capacity, weight and material

Bath No	Steel Code	Test piece dimensions	Upper yield stress or 0.2% proof stress	Tensile strength	Elongation
Bend tests satisfactory at					

For and on behalf of the manufacturer

. . . . . .

For and on behalf of the Verification Body

. . . . . .

APPENDIX 1D

Specimen Certificate for water capacity, weight and material

Manufacturer . . . . . **Date** . . . . . .

Customer . . . . . **Spec** . . . . . .

Size . . . . . **Verification Body**

Gas . . . . . **Man Order No:** . . . . . .

(Customer . . . . . .

Serial No(s)

(Manufacturer . . . . . .

Customer's Order No: . . . . . .

Batch No(s) . . . . . .

We hereby certify that the cylinders produced to design certificate number . . . . . .
comply with the following requirements.

Minimum cylindrical shell thickness

The wall thickness of all cylinders has been measured and found to be not less than ..... mm. Each cylinder has been X-Ray tested 100% of circumferential and longitudinal seams and found to be satisfactory.

Heat treatment - Stress-Relived

All containers have been treated at the following temperatures: 540 - 850°. (hydrogen sulphide cylinders to be normalised after welding).

Hydraulic pressure tests

Each cylinder has been proof tested to a pressure of ..... bar and found to be satisfactory.

Date of press tests: . . . . . .

Ultrasonic tests

Each cylinder has been ultrasonically examined on the parallel walls to a 5% standard and found to be satisfactory.

Cylinders meet requirements of ADR-RIV and IMDG-CODE.

APPENDIX II

Ultrasonic defect detection and thickness measurement

II.1 DEFECT

II.1.1 General

This method covers the pulse echo testing of welded steel cylinders.

II.1.2 Surface condition

Both the surface and the reflection surfaces of the cylinder shall be clean and free from any materials that will interfere with the test, eg loose scale.

II.1.3 Equipment

The test equipment shall be of the pulse type and shall be capable of detecting the calibration notches to the degree required in the calibration procedure specified in II.1.5.

II.1.4 Couplant

A coupling method that ensures adequate transmission of ultrasonic energy between the testing probe and the cylinder shall be used.

II.1.5 Calibration standards

II.1.5.1 A calibration standard of a convenient length shall be prepared from a cylinder of similar diameter and wall thickness, material surface finish and metallurgical condition to the cylinder to be inspected. The calibration standard shall be free from discontinuities which may interfere with the detection of the reference notches.

II.1.5.2 A longitudinal and transverse reference notch shall be introduced on the outer and inner surfaces of the calibration standard. The transverse and longitudinal notches may be positioned within 25 mm of each other but the pairs of notches on the inner and outer surfaces shall be separated by at least 50 mm along the axis of the standard.

The standard notches shall be 25 ± 0,25 long and their width shall not be more than twice the nominal depth. The notch depth shall be 5% of the minimum wall thickness or 0,25 mm, whichever is the greater. The tolerance on depth shall be ± 10% of the nominal notch depth. The cross section of the notch

shall be nominally of rectangular section but if spark erosion methods are employed the bottom of the notch may be rounded.

II.1.6 Calibration of equipment

Using the calibration standard specified in II.1.5 the equipment shall be adjusted to produce clearly identifiable indications from inner and outer surface notches. The relative response from notches shall be as near equal as possible. The indication of smallest amplitude shall be used as the rejection level and for setting visual, electronic monitoring or recording devices.

The equipment shall be calibrated with the reference standard and/or probe moving in the same manner, in the same direction and at the same speed as will be during the inspection of the cylinder.

II.1.7 Frequency

The ultrasonic test frequency shall be between 2 MHz and 6 MHz.

II.1.8 Assessment of results

Any cylinder not showing a defect indication shall be considered to have passed this ultrasonic inspection.

Note: *A defect indication is one that is equal to or greater than the less indication of the reference notches.*

If surface defects are removed by grinding than after correction the cylinder shall be resubjected to ultrasonic defect detection and thickness measurement.

APPENDIX IIA

Report No: . . . .

Report on Radiographic Examination

Sheet . . . **out of** . . . . **Sheets**

Details on Object	Manufacturer:		Purchaser:	
	Object:		Construction Drawing:	
	Material:		Dimensions:	
	Welding Procedure:		Extent of Tests:	
Technical Test Data	Source of radiation: (e.g. g- or X-rays)		Manufacturer and Type of Film:	
	Image Quality Indicator:	Foils: v	h	Manufacturer and Type of Film: Distance from Source of Radiation- to Surface of Workplace:
	Tube Voltage: kV Tube Current: mA		Activity ps^{-1}	
	Time of Exposure:		Size of Focus/Source of Radiation mm . mm	
	Requirements: AD-Merlblatt HP 5/3 and			
	Tested after/before Heat Treatment:			
	Place and Date of Tests:			

Test Results

Test Section	Name of Film	Arrangement of Exposures DIN 54111	BZ DIN 54 109	Finding [1])	Valuation [2])		Remarks
					Factory	TÜO	

[1]) Abbreviation according to DIN 8524

[2]) 1 = no defects, 2 = slight defects, 3 = defects which need not be repaired, 4 = defects where the weld needs repairing, 5 = defects requiring a new weld.

For random sample test
cc. to AD-Merkblatt HP 5/3. Point 4.2

. . . .

Date | Test Supervisor | The Inspecting Authority

Report No: . . . .

Sheet: . . . .

Radiographic Examination

Test Section	Name of Film	Arrangement of Exposures DIN 54111	BZ DIN 54 109	Finding [1])	Valuation [2])		Remarks
					Factory	TÜO	