BRITISH STANDARD

BS EN
14638-1:2006

Transportable gas cylinders — Refillable welded receptacles of a capacity not exceeding 150 litres —

Part 1: Welded austenitic stainless steel cylinders made to a design justified by experimental methods

The European Standard EN 14638-1:2006 has the status of a British Standard

ICS 23.020.30

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 14638-1:2006.

The UK participation in its preparation was entrusted by Technical Committee PVE/3, Gas containers, to Subcommittee PVE/3/3, Transportable gas containers, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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EUROPEAN STANDARD

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English Version

Transportable gas cylinders - Refillable welded receptacles of a capacity not exceeding 150 litres - Part 1: Welded austenitic stainless steel cylinders made to a design justified by experimental methods

Bouteilles à gaz transportables - Récipients soudés rechargeables d'une capacité inférieure ou égale à 150 litres - Partie 1: Bouteilles en acier inoxydable austénitique soudées, conçues selon des méthodes expérimentales

Ortsbewegliche Gasflaschen - Wiederbefüllbare geschweißte Gefäße mit einem Fassungsraum von nicht mehr als 150 Liter - Teil 1: Flaschen aus geschweißtem, austenitischen, nichtrostendem Stahl, ausgelegt nach experimentellen Verfahren

This European Standard was approved by CEN on 23 March 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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

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Foreword

This document (EN 14638-1:2006) has been prepared by Technical Committee CEN/TC 23 “Transportable gas cylinders”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2006, and conflicting national standards shall be withdrawn at the latest by November 2006.

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

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

Introduction

The purpose of this European Standard is to provide a specification for the design, manufacture, inspection and approval of welded austenitic stainless steel gas cylinders for use in the countries of the CEN members.

The specifications given in the present standard establish the methodology to be adopted in order to demonstrate that a cylinder conforms to the functional requirements demanded, based on the experience about materials, design prescriptions, manufacturing processes and controls manufacturing.

This European Standard comprises experimental methods and appropriate stress analysis calculations. It does not cover methods exclusively by means of traditional calculation.

1 Scope

This European Standard gives minimum requirements concerning material, design, construction and workmanship, procedures and tests at manufacture of refillable transportable welded cylinders made of austenitic stainless steel, justified by experimental methods, of water capacities from 0,5 l up to and including 150 l for compressed or liquefied gases and of a test pressure up to 90 bar.

NOTE This European Standard may also be used as a guideline for cylinders less than 0,5 litres water capacity.

This European Standard is primarily for industrial gases other than LPG but may also be applied for LPG. However for dedicated LPG cylinders, see EN 14140, *Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) – Alternative design and construction* prepared by CEN/TC 286 *Liquefied petroleum gas equipment and accessories*.

2 Normative references

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

EN 287-1, *Qualification test of welders - Fusion welding - Part 1: Steels*

EN 473, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

EN 910, *Destructive tests on welds in metallic materials — Bend tests*

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

EN 970, *Non-destructive examination of fusion welds — Visual examination*

EN 1435, *Non destructive examination of welds — Radiographic examination of welded joints*

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

EN 10028-7, *Flat products made of steels for pressure purposes — Part 7: Stainless steels*

EN 10045-1, *Metallic materials — Charpy impact test — Part1: Test method*

EN 10088-2*, Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*

EN 13445-2, *Unfired pressure vessels — Part 2: Materials*

EN ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid (ISO 3651-2:1998)*

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003)*

EN ISO 7539-6, *Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens for tests under constant load or constant displacement (ISO 7539-6:2003)*

EN ISO 10692-2, *Gas cylinders — Gas cylinder valve connections for use in the microelectronics industry — Part 2: Specification and type testing for valve to cylinder connections (ISO 10692-2:2001)*

EN ISO 11114-1, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials (ISO 11114-1:1997)*

prEN ISO 13769: 2005*, Gas cylinders — Stampmarking (ISO 13769:2002)*

EN ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules (ISO 15607:2003)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

ISO 2504:1973, *Radiography of welds and viewing conditions for films — Utilization of recommended patterns of image quality indicators (I.Q.I.)*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
yield stress
either the 0,2 % proof stress, $R_{p0,2}$, – or the 1,0 % proof stress, $R_{p1,0}$ where there is no apparent definite value for $R_{p0,2}$, as for example, is the case for austenitic steels

3.1.2
solution annealing
heat treatment in which the steel is heated to a uniform temperature above the solid solubility temperature followed by rapid cooling

3.1.3
parent material
material corresponding to the cylinder after finishing its manufacturing process and ready for service/operation

NOTE The material characteristics may be variable at any point of the cylinder.

3.1.4
batch
consists 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 for each pressure containing parts on the same automatic welding machines and, if applicable, heat-treated under the same conditions of temperature and duration

NOTE 1 In this context consecutively need not imply continuous production.

NOTE 2 This definition allows different suppliers to be used for the different pressure containing parts within a batch, e.g. one supplier for heads, another for bases.

3.1.5
cylinder
transportable pressure receptacle of a water capacity not exceeding 150 l

3.1.6
finished cylinder
cylinder which is fully assembled and appropriately stampmarked, but without any external coatings

3.1.7
cryoforming
process where the cylinder is subjected to a controlled low temperature deformation treatment that results in a permanent increase in strength

3.1.8
coldforming
final deformation treatment at ambient temperature given to the prefabricated cylinder, known as the preform, which results in a permanent increase in the material strength

3.1.9
valve boss or pad
connection between valve and cylinder

3.2 Symbols

a Minimum thickness, in millimetres, for calculation of weld clearance (see Figure 1);

a_{si} calculated minimum thickness, in millimetres, at a determined area "i" of the cylinder;

a_{bi} minimum thickness, in millimetres, at a determined area "i" of the cylinder (including any corrosion allowance) guaranteed by the manufacturer;

Ai percentage elongation after fracture, at a determined area "i" of the cylinder;

i area of the cylinder used for the calculation under consideration;

L, original gauge length, in millimetres, in accordance with EN 10002-1;

n ratio of diameter of bend test former to the thickness of the test piece;

P_h test pressure, in bar, above atmospheric pressure;

P_b minimum burst pressure, in bar;

P_{ba} actual burst pressure, in bar;

$R_{pi1,0}$ minimum value of 1,0 % proof stress in MPa, guaranteed by the cylinder manufacturer for the finished cylinder, at a determined area "i" of the cylinder;

R_{gi} minimum value of tensile stress, in MPa, guaranteed by the cylinder manufacturer for the finished cylinder, at a determined area "i" of the cylinder;

R_{mi} actual value of tensile stress, in MPa, determined by tensile test specified in Clause **7**, at a determined area "i" of the cylinder;

R_{ei} yield stress means the stress at which a permanent elongation of 1 % of the gauge length on the test-piece, has been produced, at a determined area "i" of the cylinder;

R_{eai} actual value of yield stress used for calculation, in MPa, at a determined area "i" of the cylinder;

s nominal butt weld thickness.

4 Materials and heat treatment

4.1 General

4.1.1 The cylinder materials subject to pressure shall be of austenitic stainless steel according to EN 10088 or EN 10028-7 or other austenitic stainless steels standards, provided that they satisfy the requirements of this European Standard.

NOTE These materials correspond to the materials received by the manufacturer, before having been submitted to any manufacturing process.

4.1.2 The welding consumables shall be such that they are capable of giving consistent welds. The material characteristics on the welds shall have to be considered by design.

4.1.3 Grades of steel used for the cylinder manufacture shall be compatible with the intended gas service, e.g. corrosive gases, embrittling gases according to EN ISO 11114-1.

4.1.4 There is a risk of sensitisation to inter-granular corrosion resulting from the hot processing of austenitic stainless steels. An inter-granular corrosion test in accordance with **7.5.4** shall be carried out on such stainless steels when intended to be used for corrosive applications. Corrosive gases are listed in EN 1968 and cylinders for such gases shall be marked as specified in prEN ISO 13769.

4.1.5 The manufacturer shall be able to guarantee cylinder steel casting traceability for each pressure retaining part.

4.1.6 All parts welded to, or in contact with, the cylinder shall be made of compatible material with the cylinder without harming its characteristics or favouring corrosion processes.

4.1.7 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 and of welding consumables.

4.1.8 The manufacturer shall demonstrate that the material is resistant to stress corrosion cracking. Where there is any doubt, tests shall be carried out on finished cylinders according to EN ISO 7539-6 or equivalent. The manufacturer shall assess the results according to the type of steel and the relevant environment under consideration.

4.2 Heat treatment

There is no obligation to perform heat treatments. When the manufacturer considers the necessity of a heat treatment, it should be in accordance with Annex D.

4.3 Test requirements

The material of the finished cylinders shall satisfy the requirements of Clause **7**.

4.4 Failure to meet test requirements

4.4.1 In the event of failure to meet test requirements, retesting shall be carried out as given in **4.4.2** and **4.4.3**.

4.4.2 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 the test is satisfactory, the first test shall be ignored.

4.4.3 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 inappropriate heat treatment (if applied), the manufacturer may subject all the cylinders of the batch to a further heat treatment;

— if the failure is not due to inappropriate heat treatment (if applied), all the identified defective cylinders shall be rejected or repaired by an approved method. The remaining cylinders are then considered as a new batch.

In both cases the new batch shall be tested. All the relevant prototype or batch tests needed to prove the acceptability of the new batch shall be performed again and shall satisfy the requirements for batch or prototype testing.

If one or more tests prove even partially unsatisfactory, all the cylinders of the batch shall be rejected.

5 Design

5.1 General

For any new design, the concepts outlined in **5.2** and **5.3** shall be followed. It is recommended that an approximate calculation for the initial design be made. This initial calculated design may then be optimised if results from the experimental method exceed the minimum requirements.

5.2 Calculation

Where a calculation is to be used as the basis for the design, the following conditions shall be considered.

— the calculation of the wall thickness of the pressure containing parts "i" shall be related to the yield stress of the material, of the finished product in each area "i" to be considered;

— for calculation purposes, the value of the yield stress R_{eai}, is limited to a maximum of 0,85 R_{gi};

— The internal pressure upon which the calculation of gas cylinders is based, shall be the test pressure P_h.

NOTE At the test pressure, the stress in the metal at the most severely stressed point of the cylinder shall not exceed 77 % of the guaranteed yield stress (R_{eai}). This can be verified by for example, studying the stress analysis.

5.3 Experimental method

An experimental method shall be used as the basis for the design. The following conditions shall be met.

— the actual wall thickness, mechanical properties and the geometry of the cylinders submitted to the prototype tests shall be recorded;

— the manufacturer shall take into account the requirements of **7.2** and ensure that the properties recorded represent the minimum values that would be used for production.

5.4 Openings

5.4.1 Each opening in the cylinder shall be reinforced, either by a valve boss or pad, of weldable and compatible steel, securely attached by welding and so designed as to be of adequate strength and to result in no harmful stress concentrations. This shall be confirmed by prototype testing.

5.4.2 When openings in the cylinder are reinforced, either by a valve boss or pad, they shall be of weldable and compatible steel, securely attached by welding and so designed as to be of adequate strength and to result in no harmful stress concentrations. This shall be confirmed by prototype test.

5.4.3 Openings shall be clear of longitudinal and circumferential joints by a distance not less than 3*a* (see Figure 1).

6 Construction and workmanship

6.1 Manufacturing methods

6.1.1 The essential characteristics of the manufacturing processes applied and the corresponding parameters shall be defined in the technical specification of the cylinder (see **7.1**).

6.1.2 The manufacturer shall have the technical capability, have at his disposal all appropriate means, and qualified personnel to carry out the manufacture of cylinders.

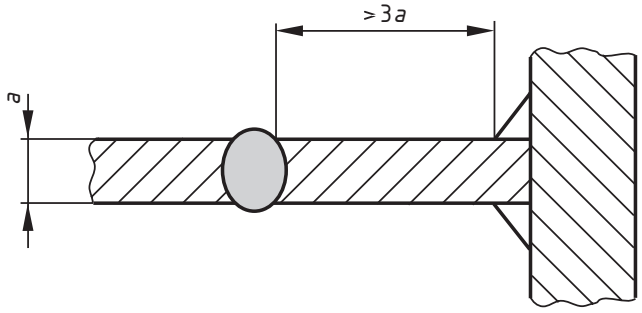


Figure 1 — Weld clearance

6.2 Welding procedures

Each manufacturer, before proceeding with the production of a given design of cylinder, shall qualify the welding procedures and welders according to EN ISO 15614-1, EN ISO 15607 and EN 287-1. Records of such qualification shall be kept on file by the manufacturer.

The welding procedure approval shall include a sensitisation test performed according to EN ISO 3651-2.

6.3 Plates and pressed parts

Care shall be taken to avoid contamination from other manufacturing materials, e.g. potential of galvanic corrosion from carbon steel particles.

6.4 Welded pressure containing joints

With exception of welds for openings, all welded joints shall be butt welded or joggle welded. When designing the welds, the cylinder manufacturer shall take into account the intended service, e.g. corrosive gases according to EN ISO 11114-1.

6.5 Non-pressure-containing attachments

6.5.1 Non pressure containing parts such as footrings, handles and neckrings which are not submitted to pressure shall be made in accordance with **4.1.6**.

6.5.2 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.

6.5.3 A footring or other suitable supports shall be fitted when applicable to the cylinder to provide stability, and attached so as to permit inspection of the welds. The footring, if attached, shall be drained and the space enclosed by the footring shall be ventilated.

6.5.4 In case of cylinders subjected to a cold-forming or cryoforming process, the non-pressure retaining attachments shall be welded to the cylinder preform before cold-forming or cryoforming.

6.6 Valve protection

6.6.1 Valves of cylinders of more than 5 l water capacity shall be effectively protected from damage that could cause release of gas, either by the design of the cylinder (for example protective shroud) or by a valve protection device (see EN 962).

6.6.2 When a protective shroud is used, it shall fulfil the requirements of the drop test (see EN 962).

6.6.3 The requirements of **6.6.1** and **6.6.2** may be waived when the cylinders are used and conveyed in bundles or cradles, or when some other effective valve protection is provided.

6.7 Cylinder openings

6.7.1 Standard openings

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

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

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

6.7.2 Special openings

If a special valve/cylinder connection is used, it shall be checked that it conforms to EN ISO 10692-2.

6.8 Visual examination

6.8.1 Unacceptable defects

Before assembly, the pressure containing parts of the cylinder shall be examined for uniform quality and freedom from unacceptable defects (see Annex C).

6.8.2 Welds

6.8.2.1 Before the cylinders are closed, the welds shall be visually examined from both sides. Permanent backing strips shall not be used with longitudinal welds.

6.8.2.2 All welds shall have a smooth finish without concavity and shall merge into the parent material without under-cutting or abrupt irregularity.

6.8.2.3 All welds shall have full penetration.

6.8.2.4 Radiographic examination, or radioscopic examination, or NDT examination carried out using another suitable method shall be as specified in Annex B.

6.9 Dimensional tolerances

6.9.1 General

The dimensional tolerances shall conform to the approved design drawing. In addition the following (**6.9.2** to **6.9.**4) shall apply for cylindrical shapes.

6.9.2 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 2 % of the mean of these diameters.

6.9.3 Straightness

Unless otherwise agreed upon by the parties, the maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 0,3 % of the cylindrical length.

6.9.4 Verticality

When the cylinder is standing on its base, the cylindrical shell and top valve openings shall be vertical to within 1 % of the cylindrical length.

6.10 Stability

If the cylinder is designed to be free standing when resting on its bottom, the centre of gravity of the cylinder shall stay approximately in the bottom centre, in order to obtain adequate stability.

6.11 Tightness

Tests appropriate to the manufacturing process shall be carried out to ensure that there is no leakage from the cylinder in accordance with Clause **7**.

7 New design tests

7.1 General requirements

The requirements of this clause shall be used, as appropriate, in accordance with the methods of conformity assessment selected by the manufacturer. Each new cylinder design shall form the subject of a prototype test.

A technical specification of the cylinder (or cylinder family), including design drawing, design calculation where appropriate, thicknesses and tolerances, specification for tests, material details, welding and manufacturing process and heat treatment, shall be made available by the manufacturer.

7.2 New designs

A cylinder shall be considered to be of a new design compared with an existing approved design when:

— it is manufactured in a different factory, or

— it is manufactured by a different welding or manufacturing process or a radical change in an existing process, e.g. change in heat treatment, or

— it is manufactured from a steel of different specified composition range, or

— if there is a change in shape or curvature of the determined areas "i", or

— the guaranteed minimum yield stress ($R_{pi1,0}$ and/or tensile strength (R_{gi}), and/or elongation (Ai) has been changed, or

— if the water capacity or gross weight have been increased, or

— if the guaranteed wall thickness have been decreased, or

— the hydraulic test pressure has been changed (where the cylinder is to be used for a lower pressure duty from that approved at the design approval stage, it shall not be deemed a new design).

7.3 Cylindrical walled cylinders

For cylinders with cylindrical walls there is no need to repeat prototype testing for a family of cylinders, with the same diameter and shape, when the length of the cylindrical part of the cylinder has been reduced from the length of the prototype cylinder.

7.4 Valve protection

If a change in the method of valve protection is made, only tests related to valves protection shall be repeated in accordance with EN 962.

7.5 Prototype tests

7.5.1 General

For the purpose of these tests, a minimum of 50 cylinders, which are guaranteed by the manufacturer to be representative of new design, shall be made available for prototype testing. However, if the total production is less than 50 cylinders, enough cylinders shall be made to complete the prototype tests required, in addition to the production quantity. In this case the type approval validity is limited to the particular batch.

7.5.2 Verification and testing

a) In the course of the type approval process, It shall be verified that:

— the conditions specified in Clause **4** (materials) are fulfilled;

— the design conforms to the requirements of Clause **5**;

— the thickness of the walls in all determined areas "i" of two cylinders meet the requirements of the agreed technical specification with respect to the guaranteed minimum thickness (a_{bi}). The measurements shall be taken on at least three locations for each determined area "i".

— the requirements of Clause **6** (construction and workmanship) and Annex B (radiographic examination) are conformed to for all cylinders selected for the tests;

— the internal and external surfaces of the cylinders at warring stages of production are free of any defect which may make them unsafe (see Annex C);

NOTE It may be necessary to section finished cylinders to undertake this inspection.

b) The following shall be performed on cylinders selected after the welds of the cylinders have been visually inspected:

— the tests specified in **7.5.3** - Fatigue testing. Two cylinders. The cylinders shall bear all representative markings.

— the tests specified in **7.5.4**, when applicable. - Corrosion test.

— the tests specified in **7.5.5** - Drop test. Six cylinders. The cylinders shall bear all representative markings;

— the tests specified in **7.5.3**; **7.5.4**; **7.5.5** and **7.5.6** - Mechanical testing. Two cylinders. The test pieces shall be identifiable with the batch;

— the tests specified in **7.7** - Hydraulic burst test. Two cylinders. The cylinders shall bear all representative markings.

These tests are to be performed on finished, unpainted cylinders, after all manufacturing processes have been completed.

7.5.3 Fatigue tests

The fatigue tests shall be carried out on two cylinders, bearing all representative stamp markings (see Clause **8**). This test shall be carried out on two cylinders for each type approval, with a non-corrosive liquid subjecting the cylinders to successive reversal at an upper hydraulic pressure equal to the test pressure, in which case the cylinder shall be subjected to 12 000 cycles without leakage or failure.

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

The frequency of reversals of pressure shall not exceed 5 cycles/min. The temperature measured on the outside surface of the cylinder shall not exceed 50 °C during the test.

After the test, one cylinder shall be sectioned in order to measure the profile and to ascertain that this profile is sufficiently close to that prescribed in the design.

The second cylinder shall be subjected to a burst test in accordance with **7.7**.

7.5.4 Corrosion test

An inter-granular corrosion test shall be carried out on two specimens obtained from one cylinder for each type approval in accordance with **4.1.5**. The specimens shall be taken from the part of the cylinder providing a specimen geometry suitable for bend testing.

Exact location of the samples shall be specified and agreed upon by the parties both shall include samples taken from welded areas.

Corrosion tests carried out for other type approvals (except material and/or heat treatment changes) shall be considered applicable to type approvals for new designs.

7.5.5 Impact test

7.5.5.1 General

7.5.5.1.1 The integrity of the cylinder shell, of the specified thickness(es), materials and mechanical properties, to withstand loadings other than internal pressure shall be demonstrated by a series of impact tests.

The specified impact energy and striking velocity shall be achieved by striking the test cylinder with a moving striker or by dropping the cylinder from an appropriate height. In all cases, the location of the impact shall be as specified in the test procedure and the direction of impact shall pass through the axis of the cylinder.

The strikers (flat surface and edge) shall be of metallic material having a hardness that is higher than that of the cylinder and sufficiently robust to prevent the impact energy being absorbed by deflection of the striker.

7.5.5.1.2 The cylinders tested shall have representative minimum thickness and shall be completely finished including the permanent protective devices.

7.5.5.1.3 The cylinders shall be filled with water so that the total mass corresponds to, at least to the maximum content foreseen (gross weight of gas cylinders) or reach this weight through an effective system. In no case shall the total contents of the cylinders exceed 95 % of the water capacity. Cylinders used for permanent gases shall be filled with water to 40 % of the water capacity of the cylinder. In neither case shall the cylinder be pressurized for the drop test (see Figure 2).

7.5.5.1.4 The choice of the impact areas of the cylinder shall correspond to the most critical zones, taking into account the shape of the cylinder, the protective elements and the foreseen handling systems. Consideration shall be given to areas of minimum thickness, welds, areas hardened due to deformation. The impact areas selected shall be agreed with the parties and recorded in the test report.

7.5.5.2 Flat surface impact test

The striker shall be a flat surface with a length equal to the overall cylinder length and width equal to the cylinder diameter.

The impact energy, F, shall be determined by:

$F = 30\ M$

where

F is the energy, in Joules;

M is the maximum operating mass of the cylinder, in kg.

The striking velocity, v, shall be between 7 m/s and 8 m/s.

Two un-pressurised cylinders shall be impacted at 5 different positions according to **7.5.5.1.4**.

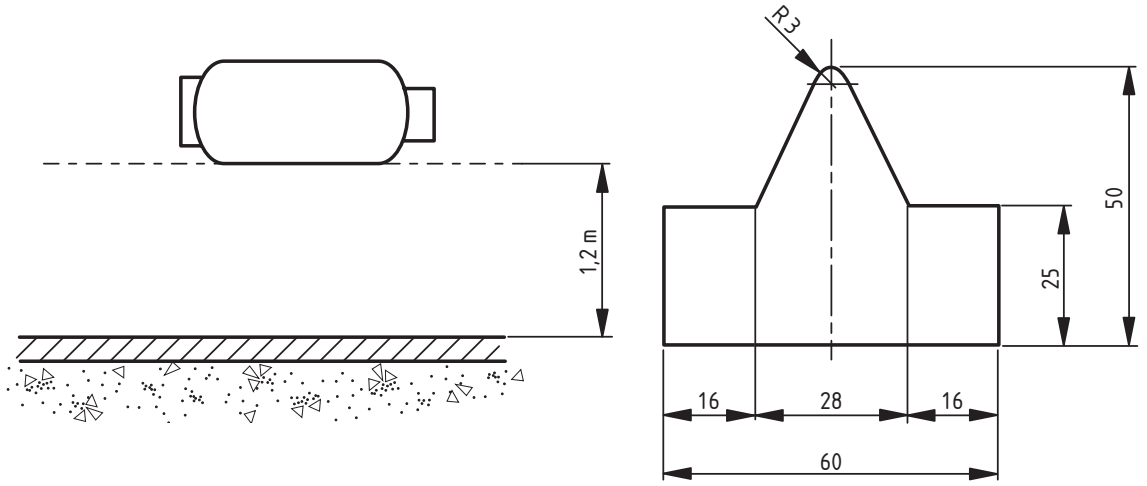
The tests shall be repeated with two further cylinders. These cylinders shall be pressurised with compressed air or any other inert gas to the maximum working pressure or 5 bar, whichever is the lower.

NOTE Appropriate measures should be taken (e.g. in a cage) to ensure safe operation and to contain any energy that may be released, which is considerably more than that in the hydraulic test.

If the cylinders withstand all of the impacts without leakage and with damage in excess of the criteria listed in EN 1803, then on completion of the impacts, both cylinders shall be subjected only to a burst test. The results shall be satisfactory when the burst pressure $P_{ba} > 1{,}3\ P_h$

If the cylinders withstand all of the impacts with visible damage below the rejection criteria (see EN 1803), then on completion of the impacts, one cylinder subject to a fatigue test in accordance with **7.5.3** but with only 6 000 cycles and one cylinder shall be subjected to a burst test in accordance with **7.7**.

Dimensions in millimetres



(a) (b) Striker details

Figure 2 — Impact tests

7.5.5.3 Edge impact test

The impact energy, F, shall be determined by:

F = 12 M

where

F is the energy, in Joules;

M is the maximum operating mass of the cylinder, in kg.

The striking velocity, v, shall be between 4 m/s and 5 m/s.

Two un-pressurised cylinders shall each be impacted with the edge parallel to the cylinder axis (see Figure 2). The cylinders shall then be impacted with the edge perpendicular to the cylinder axis. The tests shall be repeated with two further cylinders. These cylinders shall be pressurised with compressed air or any other inert gas to the maximum working pressure or 5 bar, whichever is the lower.

NOTE Appropriate measures should be taken (e.g. in a cage) to ensure safe operation and to contain any energy that may be released, which is considerably more than that in the hydraulic test.

If the cylinders withstand all of the impacts without leakage and with damage in excess of the criteria listed in EN 1803, then on completion of the impacts, both cylinders shall be subjected only to a burst test. The results shall be satisfactory when the burst pressure P_{ba} > 1,3 P_h

If the cylinders withstand all of the impacts with visible damage below the rejection criteria (see EN 1803), then on completion of the impacts, one cylinder subject to a fatigue test in accordance with **7.5.3** but with only 6 000 cycles and one cylinder shall be subjected to a burst test in accordance with **7.7**.

7.5.6 Test results

If the results are satisfactory, a type approval certificate shall be issued, a typical example of which is given in Annex D.

7.6 Production tests

7.6.1 General

All production tests shall be carried out on finished cylinders.

For the purpose of acceptance testing, the manufacturer shall provide:

— the type approval certificate **7.5.6**;

— the certificates stating the cast analyses of the steel supplied for the construction of the cylinder;

— a list of cylinders, stating serial numbers and stamp markings as required;

— information that the threads are in accordance with **6.7**.

The manufacturer shall carry out the following tests on the cylinders selected:

— mechanical testing specified in **7.5.3**; **7.5.4**; **7.5.5**; **7.5.6**;

— hydraulic burst tests specified in **7.7**;

— non destructive examination, if applicable, as referred to in Annex A;

— pressure test specified in **7.8**;

— leak test specified in **7.9**.

7.6.2 Batch sampling

7.6.2.1 For the purpose of carrying out the tests, a random sample of cylinders as indicated in Tables 1 to 3, shall be taken from each batch.

7.6.2.2 For acceptance purposes the batch shall be divided into inspection lots not exceeding 1 000 cylinders.

7.6.2.3 For selection of sample cylinders for either burst or mechanical tests, each lot shall be sub-divided into batches of 250 cylinders during the first 3 000 cylinders and batches of 500 or 1 000 cylinders, depending on burst pressure, thereafter.

7.6.2.4 The reduced rate of sampling (see Tables 2 and 3) after the first 3 000 cylinders shall be subject to the manufacturer demonstrating that the batch production test results and manufacturing processes are consistently reliable without any major interruption of manufacture (see **7.5.2.7**). This shall be considered as demonstrated if the corresponding tests on the first 3 000 cylinders are acceptable without having to repeat any test, except the repetition is due to failure in the test performance (see **4.4.2**).

7.6.2.5 In case of unsatisfactory results in any of the tests, batch controls shall be carried out as it is done at the beginning of a fabrication, although the test repetitions are correct and the batch is accepted.

7.6.2.6 For the batch less than 3 000 cylinders and for the 3 000 first cylinders of the batch greater than 3 000 cylinders see Table 1:

Table 1 — Cylinders per batch size

Batch size **Lots of 1 000 cylinders**			**Cylinders taken as samples**	**Cylinder subjected to the** **Mechanical tests**	**Burst tests**
1 st sub-lots	1 to	250	2	1 and	1
2 nd sub-lots	251 to	500	1		1
3 rd sub-lots	501 to	750	2	1 and	1
4 th sub-lots	751 to	1 000	1		1

For the next two lots of the 1 000 cylinders, repeat this sequence of tests.

7.6.2.7 For the next cylinders of the batch greater than 3 000 cylinders:

a) For burst pressure less than 1,5 P_b (1,5 x 2,25 P_h) see Table 2:

Table 2 — Cylinders per batch size

Batch size **Lots of 1 000 cylinders**			**Cylinders taken as samples**	**Cylinder subjected to the** **Mechanical tests**	**Burst tests**
1 st sub-lots	3 001 to	3 500	2	1 and	1
2 nd sub-lots	3 501 to	4 000	1	1	
after 4 000			Repeat the above sequence		

b) For burst pressures greater than 1,5 P_b i.e. greater than 1,5 x 2,25 P_h, see Table 3:

Table 3 — Cylinders per batch size

Batch size **Lots of 1 000 cylinders**			**Cylinders taken as samples**	**Cylinder subjected to the** **Mechanical tests**	**Burst tests**
sub-lots	3 001 to	4 000	2	1	and 1
after 4 000			Repeat the above sequence		

At the beginning and the end of each shift, or alignment of the welding machine, an additional bursting test or NDT examination shall be carried out. In the case of continuous production, this may be limited to one test per shift.

7.6.3 Tensile test

7.6.3.1 The tensile test on final material shall be carried out on a test sample from a finished cylinder in accordance with the requirements of EN 10002-1. The tensile test transverse to the weld shall be carried out on a test sample having a reduced section 25 mm wide over a length of 15 mm beyond the edge of the weld. Outside this central part, the width of the test sample shall increase gradually. The two faces of the test sample formed by the inside and the outside of the cylinder shall not be machined.

7.6.3.2 The values obtained for the yield stress, tensile strength, shall not be less than 95 % of those actually recorded by the cylinder manufacturer at the prototype test in accordance with **5.2** for each determined areas "*i*", and in no case be less than those given in EN 10088-2 or EN 10028-7. Lower values for mechanical properties shall result in a new prototype test from cylinders so affected.

The minimum % elongation values shall be those guaranteed by the cylinder manufacturer for each determined areas "*i*" given in the Technical Specification of cylinder (see **7.1**) and shall not be less than 14 %. However, a lower value than 14 % may also be applied, provided that appropriate measures (e.g. no fragmentation during burst testing, possible use of a safety relief device etc.) are taken to compensate for these lower values and the specific requirements are verifiable.

7.6.3.3 Tensile test samples from parent material

One tensile test sample shall be taken for each determined area "*i*" with different characteristics given in the technical specification of cylinder (see **7.1**).

7.6.3.4 Tensile test samples taken from welds

One tensile test sample shall be taken from each pressure-bearing weld except from the bung area. The tensile strength value obtained shall be at least equal to the minimum value given in the technical specification of cylinder (see **7.1**).

7.6.4 Charpy impact test

7.6.4.1 The Charpy impact test shall be carried out generally in accordance with EN 10045-1. This test is not required for cylinders manufactured from austenitic stainless steel in the solution annealed conditions and for thicknesses less than 5 mm.

7.6.4.2 The test temperature shall be at least that specified in EN 13445-2, with a minimum design reference temperature of – 50 °C. For deciding the test temperature, the actual cylinder wall thickness shall be used.

7.6.4.3 The following Charpy impact test samples shall be taken:

— three Charpy impact test samples from the final metal from areas of maximum tensile strength as stated in the technical specification of cylinder (see **7.1**);

— three Charpy impact test samples each pressure bearing weld type, except from the bung.

7.6.4.4 For the parent material, the transverse impact test pieces shall be taken from the wall of the cylinder. The notch shall be perpendicular to the face of the wall. The test pieces shall be machined on four faces only, with the inner and outer face of the cylinder wall un-machined.

7.6.4.5 In the case the radius is equal or less than 70 mm, a longitudinal impact test may be performed instead of the transverse test. Such cylinders may not have a diameter but a local radius (internal or external is possible).

7.6.4.6 For the welds, impact test pieces transverse to the weld shall be taken. The notch shall be in the centre of the weld and shall be perpendicular to the face of the cylinder. The test pieces shall be machined all over (on six faces). If the wall thickness does not permit a final test piece width of 10 mm, the width shall be as near as practicable to the nominal thickness of the cylinder wall.

7.6.4.7 The average of three specimens shall meet the values in Table 4; no specimen may show less than 70 % of average.

Table 4 — Minimum values for impact test pieces

For tensile strengths R_g	**≤ 750 MPa**		**> 750 MPa**	
Material	**Parent**	**Weld**	**Parent**	**Weld**
Impact energy, (J/cm^2)	45	45	35	35
Longitudinal (J/cm^2) for r ≤ 70 mm	60	50	50	50

7.6.5 Bend test

7.6.5.1 The bend test shall be carried out in accordance with EN 910. Specimens shall be taken in accordance with Figure 3 with dimensions as shown in Figure 4. The test samples shall be taken from the final metal from areas of maximum tensile strength as stated in the technical specification of cylinder (see **7.1**).

7.6.5.2 The face and the reverse side of the parent metal shall not be machined but shall represent the surface of the cylinder as manufactured (see Figure 4).

The following bend tests are required:

— one root and one face bend test from any longitudinal weld;

— one root and one face bend test from each circumferential weld, if made by a different welding process.

7.6.5.3 The test piece shall not crack when bent inwards around a former until the inside edges are not further apart than the diameter of the former (see Figure 4).

7.6.5.4 The ratio *n* between the diameter (D_f) of the former and the thickness (t) of the test sample shall be as shown in Table 5.

Table 5 — Bend test requirements

Actual tensile strength R_m in MPa	Value of n
$R_m \leq 440$	2
$440 < R_m \leq 520$	3
$520 < R_m \leq 600$	4
$600 < R_m \leq 700$	5
$700 < R_m \leq 800$	6
$800 < R_m \leq 900$	7
$R_m > 900$	8

7.6.6 Macroscopic examination of weld cross-sections

The cross-section of each pressure bearing weld not mechanical tested (1 cylinder per batch) shall be macroscopically tested and shall show a sound weld. All defects contravening the requirements given in EN ISO 5817 level C are inadmissible.

7.7 Burst test

7.7.1 Cylinders subjected to this test shall bear markings in accordance with the complete stamp markings required for the finished cylinder. The hydraulic burst test shall be carried out with equipment that enables the pressure to be increased at a controlled rate until the cylinder bursts and the change in pressure with time to be recorded.

7.7.2 For a test pressure (p_h) ≤ 60 bar the burst pressure (p_b) shall be at least 9/4 times the test pressure, and for a test pressure > 60 bar the burst pressure shall be equal to at least 2 times the test pressure. The burst test shall not cause any fragmentation of the cylinder. The main fracture shall not show any brittleness, i.e. the edges of the fracture shall not be radial but shall be at an angle to a diametral plane and display a reduction of area throughout their thickness.

7.7.3 If the configuration of the fracture does not conform to the requirements, a further 2 cylinders shall be burst tested to enable a decision to be reached as to the acceptance or rejection of the batch.

7.8 Pressure test

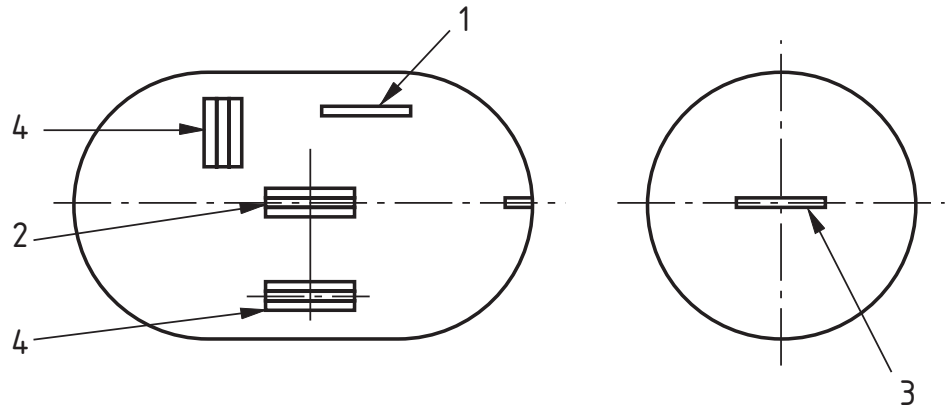
All cylinders in each batch shall be subjected to a pressure test. When carrying out a pressure test, a suitable fluid, normally water shall be used as the test medium.

NOTE A pneumatic pressure test can be substituted, provided approval from the Competent Body has been obtained. Take appropriate measures to ensure safe operation and to contain any energy which may be released, which is considerably more than that in the hydraulic test.

If water is used as the test medium, the chloride content shall not exceed 500×10^{-6} (500 ppm) to avoid the risk of corrosion with some stainless steels. The pressure in the cylinder shall be increased at a controlled rate until the pressure (p_h) is reached. The cylinder shall remain under pressure p_h for at least 30 s to establish that the pressure does not fall and that there are no leaks.

7.9 Leak test

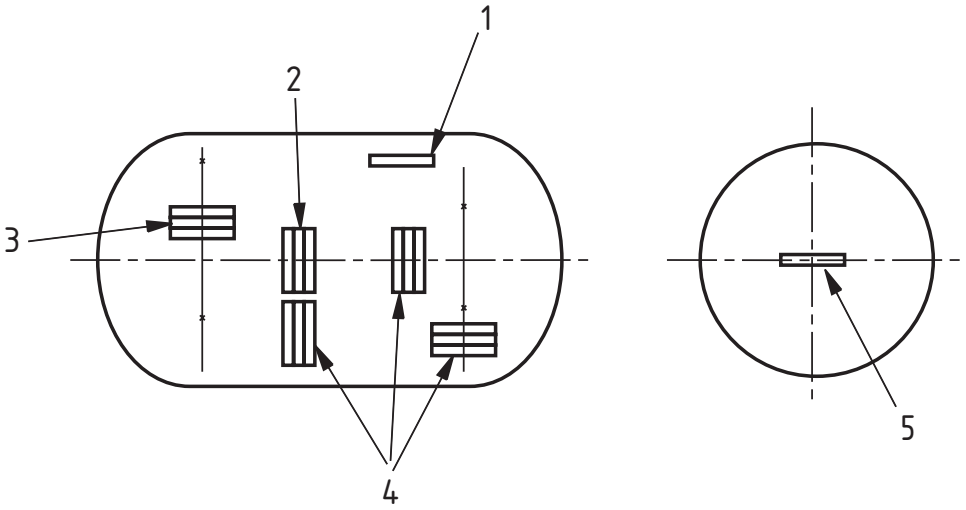
All cylinders in each batch shall be subjected to a leak test. The leak test shall be defined by the manufacturer according to the technical specification for the cylinder (see **7.1**). There shall not be any leaks.



(a) Test pieces in two-part cylinders

Key

1	1 tensile test piece
2 and 4	1 tensile test piece, root bend test piece, face bend test piece
3	1 tensile test piece. Required only if insufficient cylindrical length available



(b) Test pieces in three-part cylinders

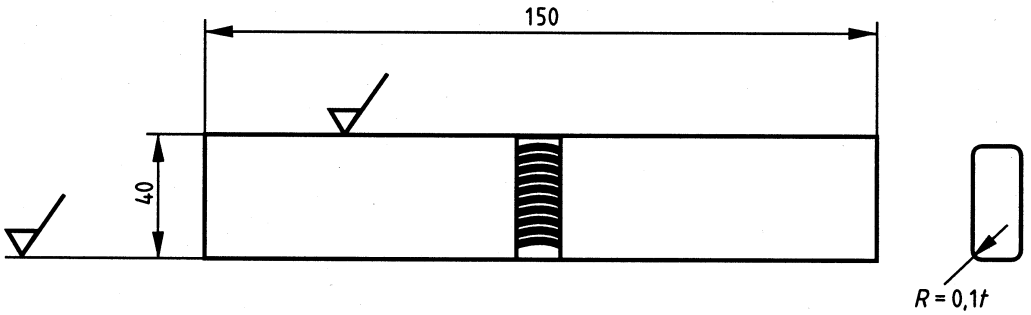
Key

1	1 tensile test piece
2	1 tensile test piece, 1 root bend test piece, 1 face bend test piece
3	1 tensile test piece, 1 root bend test piece, 1 face bend test piece. Required only if welded by a different process from longitudinal weld (see **3.1.4**)
4	impact test piece
5	1 tensile test piece

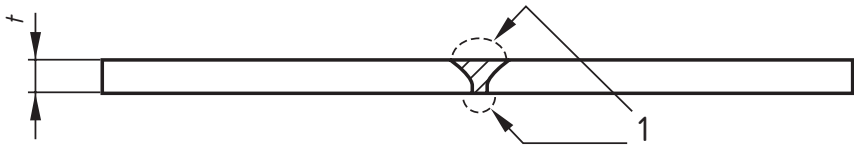
NOTE For cylinders of a different shape, the general principles of this figure should be followed in order to determine the test piece positions.

Figure 3 — Test pieces for cylindrical cylinders with an end concave to pressure

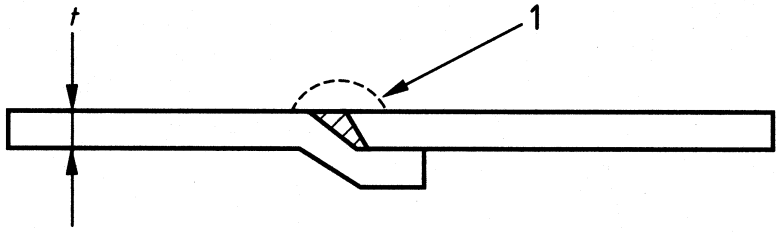
Dimensions in millimetres



(i) Specimen preparation details



(ii) Butt weld specimen

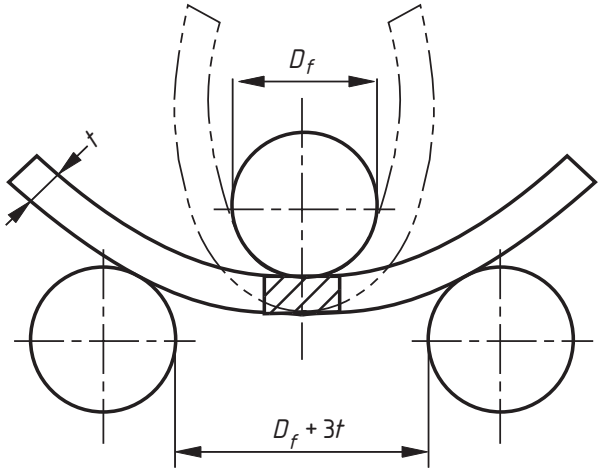


(iii) Joggle joint weld specimen

Key
1 weld dressed flush

(a) — Transverse guided bend test

Figure 4 — Bend tests



(b) — Illustration of bend test

Figure 4 — Bend tests (*concluded*)

7.10 Non destructive examination (NDE)

Annex A specifies the requirements for the NDE of cylinders.

8 Marking

Each cylinder shall be permanently and legibly marked on a nameplate or other appropriate permanently attached non-pressure part or a suitably reinforced area. Each cylinder shall be marked in accordance with prEN ISO 13769:2005.

9 Conformity evaluation criteria

The evaluation of conformity is covered by European regulations. Detailed requirements for type testing are given in **4.3**.

10 Records

A batch testing certificate shall be issued. A typical example of which is given in Annex D.

Annex A
(normative)

Non destructive examination (NDE) of welds

A.1 General

The radiographic examination shall conform to the techniques in EN 1435 class B. Radiographs shall show complete penetration of weld and freedom from unacceptable defects (as specified in Annex C). The test equipment shall be operated by personnel certified at least to level 1 of EN 473 and supervised by personnel certified at least to level 2.

The radiographic examination may be replaced by a radioscopy or another suitable method if the applied NDT method is carried out according to an approved process, and that it provides the same quality of examination as radiographic examination.

A.2 Radiographic requirements

A.2.1 The radiographic examination shall be carried out on cylinders manufactured according following Table A.1 or Table A.2:

Table A.1 — Longitudinal welds

	Actual burst pressure P_{ba}			
	$P_{ba} \leq 1{,}2\ P_b$		$P_{ba} > 1{,}2\ P_b$	
	Butt weld	**Joggle weld**	**Butt weld**	**Joggle weld**
Radiographic control frequency	1 %	2 %	1 at beginning and 1 at end / shift and machine	1 at beginning and 1 at end / shift and machine
% length	100 %	100 %	50 %	50 % min.
Intersection of joint	All	All	50 % min.	All
Overlapping zone of welds	All	All	Yes	Yes

Table A.2 — Circumferencial welds

	Actual burst pressure P_{ba}			
	$P_{ba} \leq 1{,}2\ P_b$		$P_{ba} > 1{,}2\ P_b$	
	Butt weld	**Joggle weld**	**Butt weld**	**Joggle weld**
Radiographic control frequency	1 %	1 %	1 at beginning and 1 at end / shift and machine	1 at beginning and 1 at end / shift and machine
% Length	25 %	25 %	10 %	10 % min.
Intersection of joint	50 % min.	All	50 % min.	All
Overlapping zone of welds	Yes	Yes	Yes	Yes

A.2.2 Welded joints are to be radiographed for a distance of 50 mm (25 mm on each side) beyond the intersection of the joint (see Figure A.1).

A.2.3 Assessment of the weld radiographs shall be based on the original films in accordance with the practice recommended in Clause **6** of ISO 2504:1973.

A.2.4 The following imperfections as defined in EN ISO 5817 level C shall not be permitted:

— cracks, inadequate welds or lack of penetration or lack of fusion of the weld;

— any elongated inclusion or any group of rounded inclusions in a row where the length represented over a weld length of 12 x s is greater than 6 mm;

— any gas pore measuring more than s/3 mm;

— any gas pore measuring more than s/4 mm. which is 25 mm or less from any other gas pore;

— gas pores over any 100 mm length, where the total area, in mm^2, of all the figures is greater than 2s.

A.2.5 If any of the radiographs show an unacceptable defect, the whole of the relevant shift's production shall be radiographed 100 % on all similar welds.

Until the cause of the defect has been established and rectified, the subsequent production of cylinders shall be radiographed on all similar welds.

Where more than one welding machine is used for production, the above procedure shall apply to each such machine.

Dimensions in millimetres

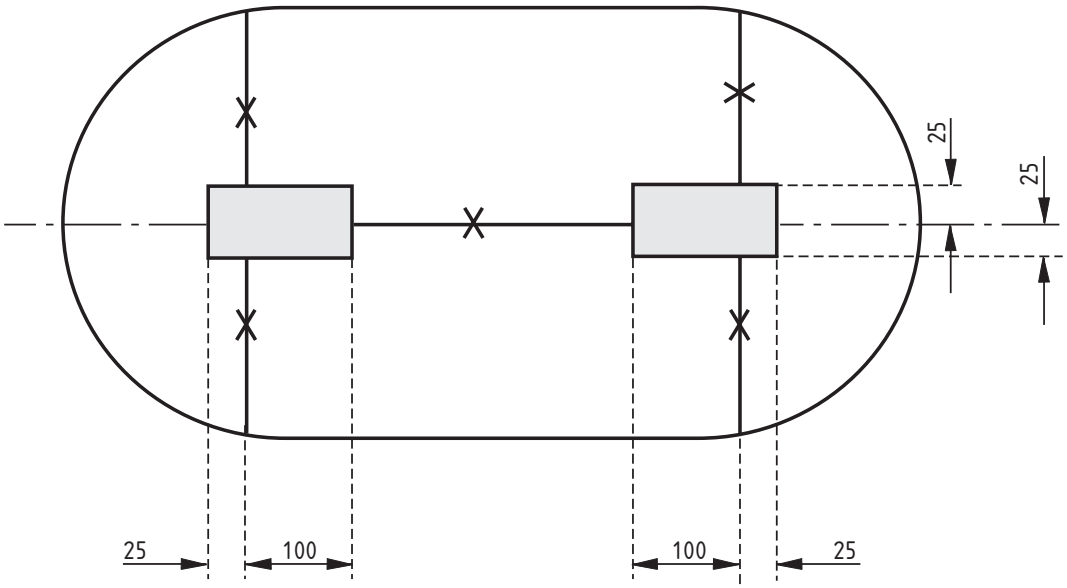


Figure A.1 — Extent of spot-radiography at weld intersections

Annex B
(normative)

Description, evaluation of manufacturing defects and conditions for rejection of welded stainless steel gas cylinders at time of final visual inspection by the manufacturer

B.1 Introduction

Several types of defects can occur during the manufacturing of a welded stainless steel gas cylinder. Such defects can be mechanical or material. They can be due to the basic material used, the manufacturing process, heat treatments, marking operations and other occurrences during manufacture.

The aim of this annex is to identify the manufacturing defects most commonly met and to provide rejection criteria to the inspectors who shall perform the visual inspection. Nevertheless extensive field experience and good judgement are necessary by the inspector to detect and to be able to evaluate and judge a defect at the time of the visual inspection (see EN ISO 5817).

B.2 General

B.2.1 Visual examination shall be carried out in accordance with EN 970. It is essential to perform the visual internal and external inspection in good conditions. Appropriate sources of illumination with sufficient intensity shall be used, e.g. at least 50 lux.

The surface of the metal and in particular of the inner wall shall be clean, dry and free from oxidation products, corrosion and scale since these could obscure more serious defects. Where necessary, the surface shall be cleaned under closely controlled conditions by suitable methods before further inspection.

When this visual inspection is carried out after the circumferential welding, the internal neck area shall be examined by means of an introscope, dental mirror or other suitable appliance.

B.2.2 Defects may be repaired in accordance with Table B.1. Great care shall be taken to avoid introducing new defects. After such repair the cylinders shall be re-examined, and, if necessary, the wall thickness shall be rechecked.

B.3 Manufacturing defects

The most commonly found manufacturing defects and their definitions are listed in Table B.1. Rejection limits for repair or reject are included in this table. These rejection limits have been established following considerable field experience. They apply to all sizes and types of cylinders and service conditions. Nevertheless some customer specifications, some types of cylinders or some special service conditions may require more stringent criteria. Rejection limits for repair or reject of weld defects shall be in accordance with EN ISO 5817 level C.

B.4 Rejected cylinders

All rejected cylinders shall be rendered unserviceable.

Table B.1 — Manufacturing defects in welded stainless steel gas cylinders

Defect	Description	Conditions	Repair/scrap
Bulge	Swelling of the cylinder	All cylinders with such a defect	Scrap
Dent	A depression in the cylinder that has neither penetrated nor removed metal (see Figure B.1) and is greater in depth than 1 % of the outside diameter	When the depth of the dent exceeds 3 % of the external diameter of the cylinder or	Scrap
		- When the diameter of the dent is less than 15 times its depth	Scrap
Cut or gouge	A sharp impression where metal has been removed or redistributed and whose depth exceeds 5 % of the cylinder wall thickness	When the depth of the cut or gouge exceeds 10 % of the wall thickness or when the length exceeds 25 % of the outside diameter of the cylinder.	Repair poss.
Lamination	Layering of the material within the cylinder wall sometimes appears as a discontinuity or crack (see Figure B.2)	- Inside defect: all cylinders with such defect	Repair if poss.
		- Outside defect: all cylinders with such defect	Repair poss.
Crack	A split or rift in the metal	All cylinders with such defects	Scrap
Internal neck threads damaged	Neck threads damaged, with dents, cuts, burrs	When the design permits it, threads may be re-tapped and re-checked by the appropriate thread gauge and carefully visually re-examined. The appropriate number of effective threads shall be guaranteed.	Repair
		- If not repairable	Scrap
Neck ring not secure	Neck ring turn and pull under application of low torque (see EN ISO 13341)	All cylinders presenting such a defect	Repair poss. according to approved method only
Non conformity with design drawing			Repair or scrap
Stamping	Marking	All cylinders with illegible, modified or incorrect markings	Repair or scrap

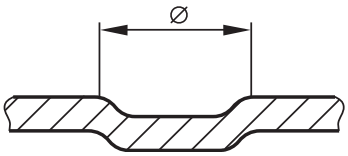


Figure B.1 — Dent

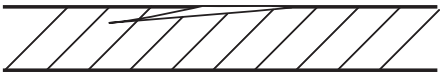


Figure B.2 — Lamination

Annex C
(informative)

Model - Production certificate

Application of CEN Standard EN 14638-1.....

Competent body .....

.....

Date .....

Type approval No .....

Description of vessels .....

.....

CEN production testing No .....

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

Manufacturer .....
(Name and address)
.....

.....

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

Owner .....
(Name and address)
.....

.....

Customer .....
(Name and address)

Production tests

1 - Measurements of sample cylinders

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

2 - Non-destructive testing results

3 - Mechanical tests carried out on sample cylinders

Test No	Heat treatment No	Test-piece in accordance with EN 10 002-1	Yield point R_{ea} (MPa)	Tensile strength R_m (MPa)	Elongation A (%)	Bend test 180° without cracking	Hydraulic burst test (bar)	Description of the fracture
Minimum values specifies								

I, the undersigned hereby declare that I have checked that the verification operations, tests and checks prescribed in CEN standard EN 14638-1……..... have been carried out successfully.

Special remarks

.....

.....

General remarks

.....

.....

Certified on (date)

.....

(Place)

.....

(Signature of the Inspector)

On behalf of

.....

(Competent body)

Annex D
(informative)

Recommendations to be applied in case of heat treatments on austenitic stainless steels

D.1 Heat treatment

Any type of heat treatment adapted to the service conditions of the cylinder may be applied. The description of the heat treatment and the parameters of this process shall be documented and included in the technical specifications of the cylinder.

The heat treatment may be performed globally on the whole cylinder, on part of the finished cylinder or on components before welding.

D.2 General requirements

Before carrying out the heat treatment cleaning has to be ensured appropriately eliminating grease, paints, marks etc.

The heating velocity shall be as quick as possible, provided that the temperature homogeneity through thickness of the mass to be treated is guaranteed. After the heat treatment the dimensions of the cylinder shall be within the tolerances defined in its technical specifications.

The heat treatment shall not produce any type of surface defect.

The heat treatment shall not produce material sensitive to intergranular corrosion, which has to be controlled in accordance with **4.1.5**.

D.3 Heat treatment control

The necessary equipment has to be arranged in order to guarantee the control of the parameters defined in the heat treatment description.

The heat treatment parameters shall be controlled and recorded.

The cylinder manufacturer shall obtain and provide certificates for the heat treatment of all pressure retaining parts.

Bibliography

[1] EN 629-1, *Transportable gas cylinders — 25E taper thread for connection of valves to gas cylinders — Part 1: Specification*

[2] EN 629-2, *Transportable gas cylinders — 25E taper thread for connection of valves to gas cylinders — Part 2: Gauge inspection*

[3] EN 1968, *Transportable gas cylinders — Periodic inspection and testing of seamless steel gas cylinders*

[4] EN 14140, *Transportable refillable welded steel cylinders for Liquefied Petroleum Gas (LPG) — Alternative design and construction*

[5] EN ISO 13341, *Transportable gas cylinders — Fitting of valves to gas cylinders (ISO 13341:1997)*

[6] EN 1803, *Transportable gas cylinders — Periodic inspection and testing of welded carbon steel gas cylinders*

[7] EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

[8] EN 10088-3, *Stainless steels — Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*

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