BRITISH STANDARD

BS EN 1968:2002
Incorporating Amendment No. 1

Transportable gas cylinders — Periodic inspection and testing of seamless steel gas cylinders

The European Standard EN 1968:2002, with the incorportion of amendment A1:2005, has the status of a British Standard

ICS 23.020.30

National foreword

This British Standard is the official English language version of EN 1968:2002, including amendment A1:2005. It supersedes BS 5430-1:1990 which is withdrawn.

The start and infish of text introduced or altered by CEN amendment is indicated in the text by tags [A1] ⟨A1]. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1] ⟨A1].

The UK participation in its preparation was entrusted by Technical Committee PVE/3, Gas containers, to Subcommittee PVE/3/7, Gas cylinder (receptacle) operations, which has the responsibility to:

— aid enquirers to understand the text;

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

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

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Transportable gas cylinders - Periodic inspection and testing of seamless steel gas cylinders

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Bouteilles à gaz transportables - Contrôles et essais périodiques des bouteilles à gaz sans soudure en acier (inclut l'amendement A1:2005)

Ortsbewegliche Gasflaschen - Wiederkehrende Prüfung von nahtlosen Gasflaschen aus Stahl (enthält Änderung A1:2005)

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This document EN 1968:2002 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 August 2002, and conflicting national standards shall be withdrawn at the latest by August 2002.

In this standard the annexes B, C, D, E, F and G are normative and the annexes A, H and I are informative.

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

This European Standard has been submitted for reference into the RID and/or 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 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, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This European Standard (EN 1968:2002/A1:2005) has been prepared by Technical Committee CEN/TC 23 “Transportable gas cylinders”, the secretariat of which is held by BSI.

This Amendment to the European Standard EN 1968:2002 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2006, and conflicting national satnadrds shall be withdrawn at the latest by April 2006

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, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

The principal aim of a periodic inspection and testing procedure is that at the completion of the test the cylinders may be reintroduced into service for a further period of time.

Experience of the inspection and testing of cylinders which is specified in this European Standard is an important factor when determining whether a cylinder should be returned into service.

1 Scope

This European Standard specifies the requirements for periodic inspection and testing of seamless steel transportable gas cylinders (single or those from bundles) intended for compressed and liquefied gases under pressure, of water capacity from 0,5 l up to 150 l.

〈A1〉 NOTE As far as practicable, this European Standard may also be applied to cylinders of less than 0,5 l water capacity and for tubes up to 3 000 l water capacity. 〈A1〉

This standard specifies the requirements for periodic inspection and testing to verify the integrity of such gas cylinders to be reintroduced into service for a further period of time. It also defines a procedure to qualify existing gas cylinders for free movement between member states of the European Union (see annex A).

This standard does not apply to periodic inspection and testing of acetylene cylinders or composite (fully wrapped or hoop-wrapped) steel cylinders.

2 Normative references

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

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

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

EN 837-1, *Pressure gauges — Part 1: Bourdon tube pressure gauges — Dimensions, metrology, requirements and testing.*

EN 837-3, *Pressure gauges — Part 3: Diaphragm and capsule pressure gauges — Dimension, metrology, requirements and testing.*

EN 1089-1, *Transportable gas cylinders — Gas cylinder identification (excluding LPG) — Part 1: Stampmarking.*

EN 1964-1, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 1: Cylinders made of seamless steel with an R_m value of less than 1100 MPa.*

prEN 1964-2, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 2: Cylinders made of seamless steel with an R_m value of 1100 MPa and above.*

EN 1964-3, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 3: Cylinders made of seamless stainless steel with an R_m value of less than 1100 MPa.*

EN 1795, *Transportable gas cylinders (excluding LPG) — Procedures for change of gas service.*

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

EN ISO 11114-2, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials (ISO 11114-2:2000).*

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

3 Intervals between periodic inspection and test

In order to ensure continued safe operation, cylinders shall be periodically submitted to inspection and test in accordance with annex B. A cylinder shall fall due for a periodic inspection and test on its first receipt by a filler after the expiry of the interval in annex B.

NOTE Table B.1 gives a list of the intervals between periodic inspections for some gases which complies with the current RID/ADR regulations and also gives recommendations which could be subsequently adopted by the RID/ADR regulations.

Provided the cylinder has been subjected to normal conditions of use and has not been subjected to abusive and abnormal conditions rendering the cylinder unsafe, there is no general requirement for the user to return a gas cylinder before the contents have been used even though the test interval may have lapsed. However it is recommended that cylinders are retested within a period not exceeding twice the time interval.

In the case of cylinders used for emergency purposes (e.g. fire extinguishers, breathing apparatus), it is the responsibility of the person in possession (owner or user) to submit it for a periodic inspection within the interval specified in annex B or as specified in the relevant cylinder design standard/regulation, if this is shorter.

4 List of procedures for periodic inspection and test

The inspection and test shall be carried out only by competent persons who shall ensure that the cylinders are fit for continued safe use.

NOTE A competent person is a person who has the necessary technical knowledge, experience and authority to assess and approve materials for use with gases and to define any special conditions of use that are necessary. Such a person will also normally be formally qualified in an appropriate technical discipline.

Each cylinder shall be submitted to periodic inspection and test. The following procedures form the requirements for such inspection and test, and are explained more fully in later clauses:

- identification of cylinder and preparation for inspection and test (clause 5);
- external visual inspection (clause 6);
- internal visual inspection (clause 7);
- supplementary tests (clause 8);
- inspection of cylinder neck (clause 9);
- pressure test or ultrasonic test (clause 10);
- inspection of valve (clause 11);
- final operations (clause 12);
- rejection and rendering cylinders unserviceable (clause 13).

Where cylinders are manufactured according to National Regulations and are intended to be qualified under the Transportable Pressure Equipment Directive (TPED) for free movement and use between member states of the European Union, additional requirements are specified in annex A.

It is recommended that the above listed tests are performed in the suggested sequence. In particular the internal visual examination (clause 7) should be carried out before the pressure test or ultrasonic test (clause 10).

Cylinders which fail the inspection or tests shall be rejected (see clause 13). When, after the above tests, doubts still exist as to the extent of a defect or the condition of a cylinder, then additional tests may be performed in accordance with clause 8, until such doubts are positively resolved or the cylinder shall be rendered unserviceable.

Some cylinders rejected during periodic inspection and test may be recovered in accordance with annex C.

5 Identification of cylinder and preparation for inspection and test

Before any work is carried out, the relevant cylinder data (e.g. see EN 1089-1) and its contents and ownership shall be identified.

If contents are identified as hydrogen or other embrittling gases only those cylinders manufactured or qualified as a hydrogen cylinder shall be used for that service. Such cylinders shall be checked that they are compatible with hydrogen service i.e. with respect to the maximum tensile strength and internal surface condition (e.g. cylinders stamp marked according to EN 1089-1 are stamped "H"). All other cylinders shall be withdrawn from hydrogen service and their suitability checked for their new intended service.

The cylinders shall be depressurized and emptied in a safe, controlled manner before proceeding. Particular attention shall be given to cylinders containing flammable, oxidizing and toxic gases to eliminate risks at the internal inspection stage.

Cylinders with incorrect markings, unknown gas contents, or those which cannot be safely emptied of gas, shall be set aside for special handling.

Cylinders with inoperative or blocked valves may be treated as outlined in annex D. Provided the requirements above have been complied with, and the cylinder has been depressurized safely, the valve shall be removed. Similarly in the case of cylinder bundles, not equipped with cylinder valves, the connecting tee junction shall also be checked to determine whether the gas is able to pass freely from the cylinder to atmosphere.

6 External visual inspection

6.1 Preparation for external visual inspection

Each cylinder shall be cleaned and have all loose coatings, corrosion products, tar, oil or other foreign matter removed from its external surface by a suitable method, e.g. by brushing, shot blasting (under closely controlled conditions), water jet abrasive cleaning, chemical cleaning or other suitable methods. Care shall be taken at all times to avoid damaging the cylinder, or removing excess amounts of cylinder wall.

If fused nylon, polyethylene or a similar coating has been applied and is seen to be damaged, or prevents a proper inspection, then the coating shall be removed. If the coating is removed by the application of heat, the temperature of the cylinder shall not exceed 300 °C.

6.2 Inspection procedure

The external surface of each cylinder shall then be inspected for:

a) dents, cuts, gouges, bulges, cracks, laminations or excessive base wear.

b) heat damage, torch or electric arc burns (as defined in Table C.1).

c) corrosion (as defined in Table C.2).

d) other defects such as illegible or unauthorized stamp markings, unauthorized additions or modifications.

e) integrity of all permanent attachments.

f) vertical stability (if relevant)(as defined in Table C.1).

For rejection criteria, see annex C. Cylinders no longer suitable for future service shall be rendered unserviceable (as defined in clause 13).

7 Internal visual inspection

Each cylinder shall be inspected internally, using adequate illumination to identify any defects such as those listed in 6.2 a) and 6.2 c). Precautions shall be taken to ensure that the method of illumination presents no hazards to the tester whilst performing the operation. Any internal liner or coating which can obstruct optimum internal visual inspection, shall be removed. Any cylinder showing presence of foreign matter or signs of more than light surface corrosion shall be cleaned internally under closely controlled conditions by shot blasting, water jet abrasive cleaning, flailing, steam jet, hot water jet, rumbling, chemical cleaning, or other suitable method. Care shall be taken to avoid damage to the cylinder. If cleaning is required, the cylinder shall be re-inspected after the cleaning operation.

For cylinders in non-corrosive gas service and less than 0,5 l water capacity with an internal neck diameter less than 9 mm, alternative methods can be substituted for the internal visual inspection.

These alternative methods are :

a) look for any free moisture at the time of degassing the cylinder whilst in an inverted position and prior to valve removal. If any moisture is present, the cylinder shall be rendered unserviceable;

and

b) look for contamination e.g. rust in the water used after the hydraulic test. If any contamination is found, the cylinder shall be rendered unserviceable.

8 Supplementary tests

Where there is doubt concerning the type and/or severity of a defect found on visual inspection (see clauses 6 and 7), additional tests or methods of examination may be applied, e.g. ultrasonic techniques, check weighing or other non-destructive tests. Only when all doubts are eliminated may the cylinder be further processed (see annex C).

9 Inspection of cylinder neck

9.1 Internal neck thread

The internal neck thread of the cylinder shall be examined to ensure that it is:

- clean and of full form;
- free of damage;
- free of burrs;
- free of cracks;
- free of other imperfections.

Cracks manifest themselves as lines which run vertically down the thread and across the thread faces. They should not be confused with tap marks (thread machining marks). Special attention should be paid to the area at the bottom of the thread.

9.2 Other neck surfaces

Other surfaces of the neck shall also be examined to ensure they are free of cracks or other defects (see annex C).

9.3 Damaged internal neck threads

Where necessary, and where the manufacturer or the competent person confirms that the design of the neck permits, threads may be re-tapped to provide the appropriate number of effective threads. After re-tapping, the threads shall be checked by the appropriate thread gauge, (e.g. for 25E threads, in accordance with EN 629-2).

9.4 Neck ring and collar attachment

When a neck ring/collar is attached, an examination to ensure that it is secure and free from thread damage shall be carried out. Neck rings shall only be changed using an approved procedure. If it is found that any significant damage to cylinder material has occurred by replacement of the neck ring/collar, the cylinder shall be rendered unserviceable. If the neck ring has been re-attached by welding or brazing, the cylinder shall be rendered unserviceable.

10 Pressure test or ultrasonic test

10.1 General

Each cylinder shall be subjected to a pressure test (see 10.2) or to an ultrasonic test (see 10.3).

10.2 Pressure test

10.2.1 General requirements

When carrying out a pressure test, a suitable fluid, normally water shall be used as the test medium. The test may be a proof pressure test (see 10.2.2) or a volumetric expansion test (see 10.2.3), as appropriate to the design of the cylinder. Having decided to use one particular type of test, its result shall be final. No attempt shall be made to transfer from one type of test to the other. The test pressure shall be in accordance with the stamping on the cylinder.

The pressure in the cylinder shall be increased gradually until the test pressure is reached. The cylinder test pressure shall be held for at least 30 s with the cylinder isolated from the pressure source, during which time there shall be no decrease in the recorded pressure or any evidence of any leakage. Safety precautions shall be taken during the test.

10.2.2 Proof pressure test

Annex E specifies a typical method for carrying out the test.

NOTE A pneumatic pressure test can be substituted, provided approval from the relevant authority has been obtained. Measures should be taken to ensure safe operation and to contain any energy, which is considerably more than that in the hydraulic test, which can be released.

During the 30 s hold period the pressure as registered on the test gauge shall remain constant.

There shall be no visible leakage or visible permanent deformation on the entire surface of the cylinder. This check may be made either during the 30 s hold or immediately after the pressure has been released.

Any cylinder failing to comply with the requirements of this test shall be rendered unserviceable.

10.2.3 Volumetric expansion test

Annex F specifies a typical method for carrying out the test and gives details for determining the volumetric expansion of seamless steel gas cylinders by the preferred water jacket method or the non-water jacket method.

The permanent volumetric expansion of the cylinder expressed as a percentage of the total expansion at test pressure shall not exceed the percentage given in the design specification after the cylinder has been held at test

pressure for a minimum period of 30 s. If this figure for permanent expansion is exceeded the cylinder shall be rendered unserviceable.

10.3 Ultrasonic test

Ultrasonic testing may be used in place of the pressure test in the procedures of periodic inspection, with the agreement of the competent person. Ultrasonic testing, if carried out, shall be in accordance with the method specified in annex G.

11 Inspection of valve

If it is to be re-introduced into service, each valve (or tee junction for bundles) shall be inspected to verify that it will perform satisfactorily and ensure gas tightness. An example of a suitable method is given in annex H.

12 Final operations

12.1 Drying, cleaning and painting

12.1.1 Drying and cleaning

The interior of each cylinder shall be thoroughly dried by a suitable method at a temperature not exceeding 300 °C, immediately after hydraulic pressure testing, such that there is no trace of free water. The interior of the cylinder shall be inspected to ensure that it is dry and free from other contaminants.

12.1.2 Painting

Cylinders are sometimes re-painted, using paints which require stoving. Plastics coatings may also be reapplied. Painting or coating shall be applied such that all markings stamped on the cylinder are legible.

In no case shall the temperature of the cylinder exceed 300 °C.

12.2 Re-valving of the cylinder

The valve shall be fitted to the cylinder using a suitable sealing material. An optimum torque necessary to ensure both a seal between the valve and the cylinder and prevent over-stressing the neck shall be used in accordance with EN ISO 13341.

The torque applied shall take into consideration the size and form of the threads, the material of the valve, and the type of sealing material used according to the manufacturer's recommendations. Where the use of lubricants/sealing material is permitted, only those approved for the gas service shall be used, taking particular care for oxygen service in accordance with EN ISO 11114-2.

12.3 Check on cylinder tare

This requirement applies only to cylinders for liquefied gases. The tare of the cylinders shall be obtained by weighing on a machine regularly checked for accuracy. The capacity of the weighing machine shall be suitable for the tare weight of the cylinders.

The tare shall include the mass of the cylinder, valve(s) and all permanent fittings. If the tare of the cylinder differs from the stamped tare by more than the value shown in Table 1 and is not due to reasons of damage, the original tare shall be cancelled and the correct tare shall be marked in a permanent and legible fashion in accordance with EN 1089-1.

Table 1 — Maximum allowable deviation in cylinder tare weight

Cylinder water capacity (V)	Maximum allowable deviation in tare weight
l	g
$0,5 \leq V < 5,0$	± 50
$5,0 \leq V \leq 20$	± 200
> 20	± 400

12.4 Stampmarking

After satisfactory completion of the periodic inspection and test, each cylinder shall be permanently marked according to EN 1089-1 with the present test date followed by the symbol of the inspection body or test station.

12.5 Reference to next test date

The next test date shall be shown in a clearly visible manner by an appropriate method such as a label or a disc fitted between the valve and the cylinder, indicating the year of the next periodic inspection or periodic inspection and test.

12.6 Identification of contents

Before the cylinder is reintroduced into service, the cylinder shall be marked according to the intended contents (see e.g. EN 1089-2 and EN 1089-3). If painting is required, care shall be exercised in accordance with 12.1.2. If a change of gas service is involved the requirements of EN 1795 shall be followed.

12.7 Records

Details of the present test shall be recorded by the test station and the following information shall be available:

- owner's name;
- manufacturer's or owner's serial number;
- cylinder tare, where applicable;
- test pressure;
- result of test (pass or fail);
- present test date;
- identification symbol of the inspection body or the test station;
- identification of inspector;
- details of any modifications made to the cylinder by the inspector.

Additionally, it shall be possible to obtain the following items of information from records, which need not necessarily be kept on a single file, but will enable a particular cylinder to be traced. These items are:

- cylinder manufacturer;
- manufacturer's serial number;

- manufacturing specification;
- water capacity/size;
- manufacturing test date.

13 Rejection and rendering cylinder unserviceable

The decision to reject a cylinder may be taken at any stage during the inspection and test procedure. If it is not possible to recover a rejected cylinder, it shall, after notifying the owner, be made unserviceable by the testing station for holding gas under pressure so that it is impossible for any part of the cylinder, especially the shoulder, to be re-issued into service.

In case of any disagreement, ensure that the legal implication of the contemplated action is fully understood.

One or a combination of the following methods can be employed to render the cylinder unserviceable, after ensuring that the cylinder is empty and free of gas (see clause 5):

- crush the cylinder, preferably in the shoulder area, using mechanical means;
- burn an irregular hole in the top dome equivalent in area to approximately 10 % of the area of the top dome or, in the case of a thin-walled cylinder pierce in at least three places;
- cut the neck in an irregular fashion;
- cut the cylinder including the shoulder into two or more irregular pieces;
- burst in a safe manner.

Annex A
(informative)

Gas cylinders manufactured according to National Regulations

A.1 Scope

This annex specifies those checks, inspections and tests which shall be performed in order to qualify existing gas cylinders, manufactured according to National Regulations, to ensure their compliance with the TPED for free movement and use between all Member States of the European Union.

The annex does not apply to and hence is not necessary for gas cylinders manufactured according to EN 1964-1, prEN 1964-2 or EN 1964-3 (see also Directive 84/525/EEC).

A.2 Definition and symbol

TT
official stamp mark required by the TPED to certify existing gas cylinders conforming to RID/ADR for use throughout the European Union

A.3 General requirements

A.3.1 The owner of the gas cylinders shall indicate to the inspection body the types and the number of gas cylinders presented for qualification.

For each of the cylinders the following information shall be made available for documentation and subsequent calculation:

- manufacturer;
- serial number;
- date of manufacture;
- regulation or specification to which the cylinder was manufactured;
- working pressure;
- test pressure;
- external diameter;
- minimum wall thickness;
- minimum yield stress;
- water capacity.

The inspection body shall verify that this list contains all the necessary information to clearly define the cylinder (see example of production testing certificate in the relevant annex of the relevant Part of EN 1964, for the above listed parameters only).

A.3.2 The inspection body shall verify that these cylinders are not on any relevant national safety related recall list. Additionally if any restrictions of use apply they shall be maintained for further use.

A.3.3 The owner shall provide information to enable the inspection body to verify that these cylinders are not or have not been in carbon monoxide or carbon monoxide mixture service.

A.3.4 The inspection body shall verify that the wall thickness of the gas cylinders is equal to, or greater than, the minimum wall thickness, as calculated in accordance with the relevant Part of EN 1964, for the corresponding yield stress of the cylinder.

A.3.5 The inspection body shall verify that cylinders intended for use in hydrogen (or other embrittling gas service) conform to EN ISO 11114-1.

A.3.6 The inspection body shall verify that the manufacturing certificates or equivalent records are available. When manufacturing certificates are not available, the inspection body shall verify that all relevant type testing and manufacturing batch testing have been performed.

A.3.7 The inspection body shall perform the periodic inspection according to this standard.

A.4 Specific requirements

If any of the general requirements in A.3.1 to A.3.6 are not fully met, the cylinder may be qualified if the inspection body is able to verify the following, as appropriate:

a) The inspection body shall verify the calculation of the minimum wall and base thicknesses.

   All the cylinders shall be ultrasonically tested according to the method indicated in annex G as appropriate to verify that the minimum wall and base thicknesses of each cylinder are equal to or greater than the minimum wall and base thickness prescribed by the relevant Part of EN 1964 and that the cylinders are free from harmful defects, as described in annex C.

b) A hardness test shall be performed on each cylinder as described in EN 1964-1. The results shall be compared to the requirements in the original specification, if available. Any significant deviation shall be indicated and explained.

   Where the hardness value is not specified a correlated hardness value shall be derived by the method as described in prEN 1964-2.

c) For steel cylinders intended for use in hydrogen or other embrittling gas service, in addition to A.3.5, pressure cycle tests as described in EN 1964-1 shall be repeated for each type of cylinder submitted. The acceptance criteria shall correspond to those described in EN 1964-1.

d) The cylinder shall be hydraulically tested in accordance with 10.1 or 10.2 if not already hydraulically tested as in A.3.7.

A.5 Special markings

A gas cylinder passing the periodic inspection may only be stamped with the mark "**ττ**" provided that the requirements under A.3 and A.4 as appropriate have been fully verified.

A.6 Inspection report

The inspection body shall prepare a report for each type of cylinder.

All relevant certifications, new tests and inspections performed shall be attached to this report.

Annex B
(normative)

Inspection periods

Table B.1 — Intervals between periodic inspections and test [a]

Description	Gas type (examples) [b]	Normative intervals [c] Period years	Informative recommendations for next revision of ADR Period years
Compressed gases	Ar, N_2, He etc.	10	10
	H_2 [d]	10	10
	Air, O_2	10	10
	Self-contained breathing Air, O_2, etc	[e]	5
	Gases for underwater breathing apparatus	[e]	2,5 (internal visual) and 5 (full) [f]
	CO [g]	5	5
Liquefied gases	CO_2, N_2O etc.	10	10 [h]
Corrosive gases	[i]	3	3 (internal visual) and 5 (full) [k]
Toxic gases	CH_3Br	5	10
Very toxic gases	AsH_3, PH_3 etc.	5	5
Gas mixtures	a) all mixtures except b) below b) mixtures completely in the gaseous state containing toxic and/or very toxic components.	3, 5 or 10 years according to classification 3 years for groups TC, TFC, TOC 5 years for groups T, TF, TO 10 years for groups A, O, F	a) Lowest test period of any component b) For such mixtures, if the toxicity of the final mixture is such that $LC_{50} \geq$ a volume fraction of 200×10^{-6}, a 10 year period applies, and if the toxicity of the final mixture is such that $LC_{50} \leq$ a volume fraction of 200×10^{-6} a 5 year period applies

[a] At all times certain requirements may necessitate a shorter time interval e.g. the dew point of the gas, polymerization reactions and decomposition reactions, cylinder design specification, change of gas service.

[b] This list of gases is not exhaustive. A full list of gases can be found in RID/ADR.

[c] These intervals conform to the 1999 edition of RID/ADR.

[d] Pay particular attention to the requirements of clause 5 and possible additional testing in accordance with EN 1795 for change of service.

[e] Not currently listed in RID/ADR.

[f] For cylinders used for self-contained underwater breathing apparatus in addition to the full retest period of 5 years, an internal visual inspection need to be performed every 2,5 years.

[g] This product requires very dry gas (see EN ISO 11114-1).

[h] This test period may be used provided the dryness of the product and that of the filled cylinder are such that there is no free water, and that this condition is proven and documented within a quality system of the filler. If these conditions cannot be fulfilled alternative or more frequent testing may be appropriate.

[i] For RID/ADR purposes, corrosivity is with reference to human tissue and NOT cylinder material, as per annex I.

[k] For gas mixtures shown to be corrosive for the cylinder material, the time period for single corrosive gases applies.

Annex C
(normative)

Description, evaluation of defects and conditions for rejection of seamless steel gas cylinders at time of visual inspection

C.1 General

Gas cylinder defects can be physical or material or due to corrosion as a result of environmental or service conditions to which the cylinder has been subjected during its life.

The object of this annex is to give general guidelines to the gas cylinder users as to the application of rejection criteria.

This annex applies to all cylinders but those which have contained gases having special characteristics can require modified controls.

Any defect in the form of a sharp notch may be removed by grinding, machining or other approved methods.

After such a repair, checking of the wall thickness, e.g. ultrasonically, shall be repeated.

C.2 Physical or material defects

Evaluation of physical or material defects shall be in accordance with Table C.1.

C.3 Corrosion

C.3.1 General

The cylinder can be subjected to environmental conditions that could cause external corrosion of the metal.

Internal corrosion of the metal can also occur owing to service conditions.

There is difficulty in presenting definite rejection limits in tabular form for all sizes and types of cylinders and their service conditions. The limits of rejection have been established following considerable field experience.

Extensive experience and judgment are required in evaluating whether cylinders that have corroded internally are safe and suitable for return to service. It is important that the surface of the metal is cleaned of corrosion products prior to the inspection of the cylinder.

C.3.2 Types of corrosion

The types of corrosion possible are classified as described in in Table C.2.

Table C.1 — Rejection limits relating to physical and material defects in the cylinder shell

Type of defect	Definition	Rejection limits in accordance with clause 6 [a]	Repair or render unserviceable
Bulge	Visible swelling of the cylinder	All cylinders with such a defect	Render unserviceable
Dent	A depression in the cylinder that has neither penetrated nor removed metal 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	Render unserviceable
		When the diameter of the dent is less than 15 times its depth	Render unserviceable
Cut or gouge (see Figure C.1)	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	Repair if possible [b]
		When the length exceeds 25 % of the outside diameter of the cylinder; or	Repair if possible [b]
		When the wall thickness is less than the minimum design thickness	Render unserviceable
Crack (see Figure C.2)	A rift or split in the metal	All cylinders with such defects	Render unserviceable
Fire damage (see Figure C.3)	Excessive general or localized heating of a cylinder usually indicated by:	All cylinders in categories a) and b)	Render unserviceable
	a) partial melting of the cylinder;		
	b) distortion of cylinder;		
	c) charring or burning of paint;	All cylinders in categories c) and d) may be acceptable after inspection and/or testing	Repair if possible
	d) fire damage to valve, melting of plastic guard or date ring.		
Plug or neck inserts	Additional inserts fitted in the cylinder neck, base or wall	All cylinders unless it can be clearly established that addition is part of approved design	Repair if possible
Stampmar-king	Marking by means of a metal punch	All cylinders with illegible, modified or incorrect or incorrectly modified markings	Render unserviceable [c]
Arc or torch burns (see Figure C.4)	Partial melting of the cylinder, the addition of weld metal or the removal of metal by scarfing or cratering	All cylinders with such defects	Render unserviceable
Suspicious marks	Introduced other than by the cylinder manufacturing process or approved repair	All cylinders with such defects	Continued use possible after additional inspection
Vertical stability		Deviation from verticality which can present a risk during service (especially if fitted with foot-ring)	Repair if possible or render unserviceable

[a] When applying the rejection criteria given in this table, the conditions of use of the cylinders, the severity of the defect and safety factors in the design shall be taken into consideration.

[b] Provided that after repair by a suitable metal removal technique, the remaining wall thickness is at least equal to the design minimum wall thickness.

[c] If it can be clearly established that the cylinder fully complies with the appropriate specifications, altered operational and modified marking may be acceptable and inadequate markings may be corrected, provided there is no possibility of confusion.

Table C.2 — Rejection criteria for corrosion of the cylinder wall

Type of corrosion	Definition	Rejection limits in accordance with clause 6 [a]	Repair or render unserviceable
General corrosion (Figure C.5)	Loss of wall thickness over an area of more than 20 % of the total surface area of the cylinder	If the original surface of the metal is no longer recognizable; or	Repair if possible
		If the depth of penetration exceeds 10 % of original thickness of wall [b]; or	Repair if possible (repeat requirements of clauses 6, 7 and 8)
		If the wall thickness is less than design minimum wall thickness.	Render unserviceable
Local corrosion	Loss of wall thickness over an area of less than 20 % of the total surface area of the cylinder except for the other types of local corrosion described below	If the depth of penetration exceeds 20 % of the original thickness of the cylinder wall [b]; or if the wall thickness is less than design thickness	Repair if possible (repeat requirements of clauses 6, 7 and 8)
Chain pitting or line corrosion (Figure C.6)	Corrosion forming a narrow longitudinal or circumferential line or strip, or isolated craters or pits (Figure C.7) which are almost connected	If the total length of corrosion in any direction exceeds the diameter of the cylinder and the depth exceeds 10 % of the original wall thickness [b]	Repair if possible [c]

[a] If the bottom of the defect cannot be seen and if its extent cannot be determined using appropriate equipment, the cylinder shall be rendered unserviceable.

[b] If corrosion has reached limits of depth or extent, the remaining wall thickness should be checked with an ultrasonic device. The wall thickness may be less than the minimum, with the acceptance of the inspection body, e.g. small (depth and extent) isolated pits. When applying the rejection criteria given in this table, the conditions of use of the cylinders, the severity of the defect and safety factors in the design shall be taken into consideration.

[c] Provided that after repair by a suitable metal removal technique, the remaining wall thickness is at least equal to the design minimum wall thickness.

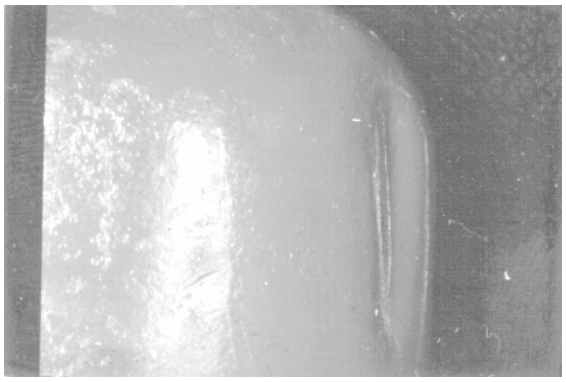


Figure C.1 — Cut or gouge

Figure C.2 — Crack

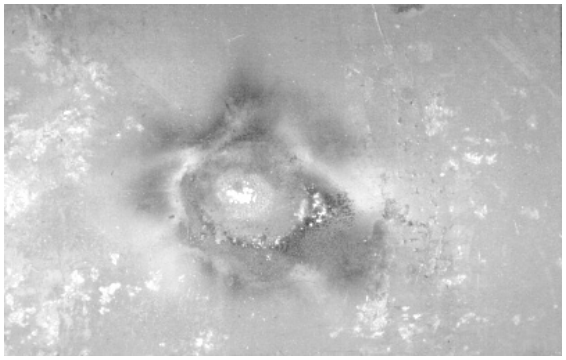


Figure C.3 — Fire damage

Figure C.4 — Arc or torch burns

Figure C.5 — General corrosion

Figure C.6 — Line corrosion

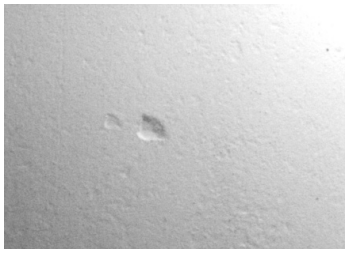


Figure C.7 — Isolated pits

Annex D
(normative)

Procedure to be adopted when a cylinder valve is suspected to be obstructed

D.1 If there is any doubt when the valve of a gas cylinder is opened, that gas is not being released and the cylinder can still contain residual gas under pressure, a check shall be made to establish that the free passage through the valve is not obstructed.

The method adopted shall be a recognized procedure such as one of the following or one that provides equivalent safeguards:

a) For cylinders of liquefied gases, first check to establish that the weight of the cylinder is the same as the tare weight stamped on the cylinder. If there is a positive difference, the cylinder may contain either liquefied gas under pressure or contaminants.

b) Introduce inert gas at a pressure of up to 5 bar and check its discharge;

c) Use the device shown in Figure D.1, to pump air into the cylinder, by hand.

D.2 When it is established that there is no obstruction to gas flow in the cylinder valve, the valve may be removed.

D.3 When a cylinder is found to have an obstructed gas passage in the valve, the cylinder shall be set aside for special attention as follows:

a) Saw or drill the valve body until interception is made with the gas passage between the valve body stem and valve spindle seat; Cooling shall be provided, especially if toxic gases are involved; or

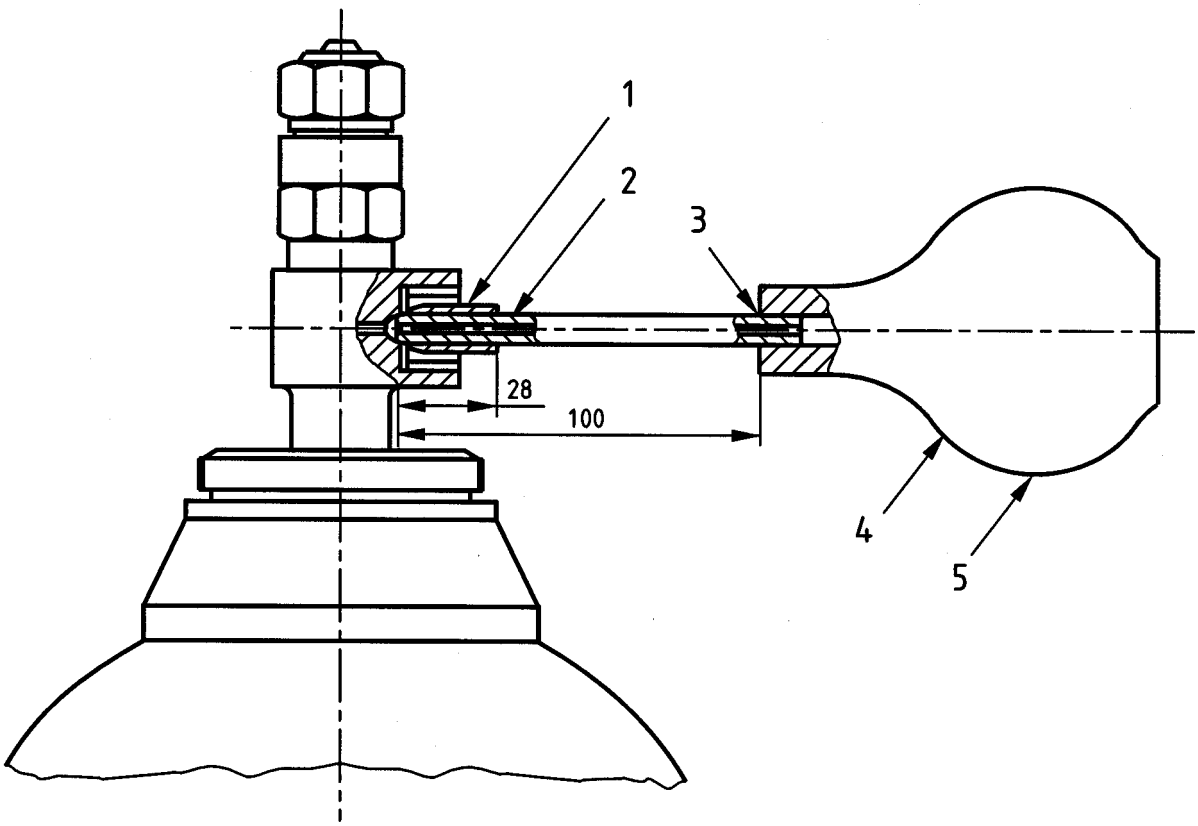
b) Loosen or pierce the safety device in a controlled manner.

These methods are applicable to cylinders of non-toxic, non-flammable, non-oxidizing and non-CFC gases. Appropriate safety precautions shall be taken to ensure that no hazard results from the uncontrolled discharge of any residual gas.

Where the contents are toxic, flammable, oxidizing or CFC, the preferred method is to unscrew partially the valve within a glanded cap, secured and joined to the cylinder and vented to a safe discharge. The principles of a suitable device are illustrated in Figure D.2.

These procedures shall be carried out only by trained personnel. When the gas, if any, has been released and the pressure within the cylinder reduced to atmospheric pressure, and, in the case of liquefied gases, when there is no frost or dew on the outside of the cylinder, the valve may be removed.

Dimensions in millimetres



Key

1 Rubber tube 8 internal diameter × 13 external diameter ground to olive shape and bonded

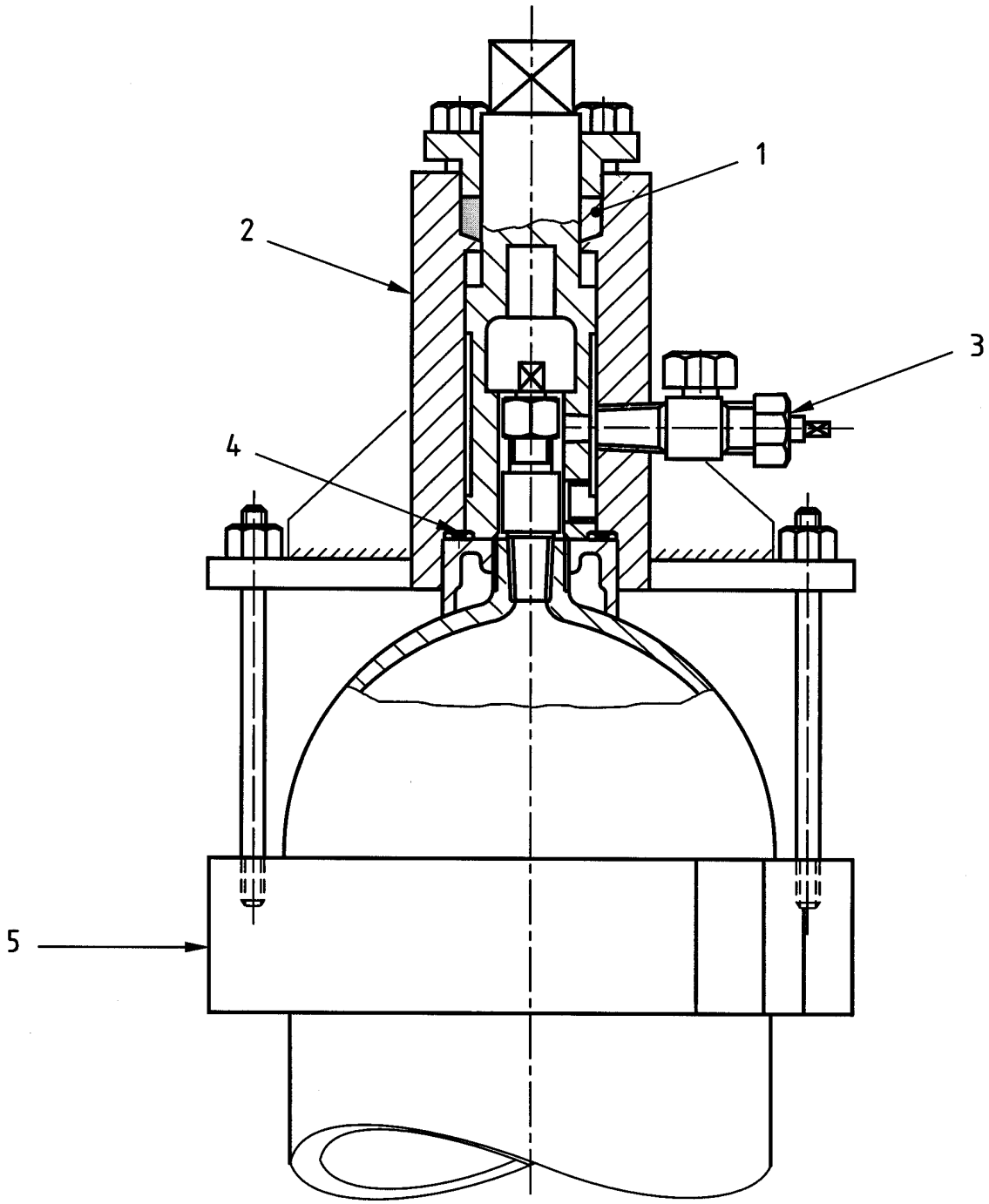
2 Copper tube 3 internal diameter × 8 external diameter

3 Bond

4 Rubber bulb

5 Hand pressure

Figure D.1 — Device for detecting obstructed cylinder valve



Key

1 Rubber gland packing
2 Extractor casing
3 Control valve
4 Joint ring
5 Clamp

Figure D.2 — Typical device for the removal of a damaged gas container valve

Annex E
(normative)

Proof pressure test of gas cylinders

E.1 General

This annex gives details of a method of carrying out a proof pressure test on gas cylinders. Other acceptable methods may be employed.

E.2 Test equipment

E.2.1 All rigid pipe work, flexible tubing, valves, fittings and components forming the pressure system of the test equipment shall be designed to withstand a pressure 1,5 times the maximum test pressure of any cylinder that will be tested. Flexible tubing shall have sufficient wall thickness to prevent kinking.

E.2.2 Pressure gauges shall be at least to accuracy class 1, as defined in EN 837-1 or EN 837-3, with a scale appropriate to the test pressure. They shall be checked for accuracy against a calibrated gauge at regular intervals, and in any case not less frequently than once a month. The pressure gauge shall be chosen such that the test pressure is approximately between $^1/_3$ and $^2/_3$ of the value capable of being measured on the pressure gauge.

E.2.3 The design and installation of the equipment, the connection of the cylinders and the operating procedures, shall be such as to avoid trapping air in the system when a liquid medium is used.

E.2.4 All joints within the system shall be leak-tight.

E.2.5 A suitable device shall be fitted to the test equipment to ensure that no cylinder is subjected to a pressure in excess of its test pressure by more than the tolerances in E.3.3.

E.3 Test method

E.3.1 More than one cylinder may be tested at a time provided that they all have the same test pressure. In case of leakage the leaking cylinder(s) shall be isolated. All other cylinders shall be re-tested.

E.3.2 Before applying pressure the external surface of the cylinder(s) shall be dry.

E.3.3 The pressure applied shall not be below the test pressure and shall not exceed the test pressure by 3 % or 10 bar, whichever is the lower.

E.3.4 On attaining the test pressure, the cylinder(s) shall be isolated from the pump and the pressure held for a minimum period of 30 s.

E.3.5 If there is a leakage in the pressure system it shall be corrected and the cylinder(s) re-tested.

Annex F
(normative)

Volumetric expansion testing of gas cylinders

F.1 General

This annex gives details of the two methods of determining the volumetric expansion of steel gas cylinders:

a) the water jacket method (preferred method);

b) the non-water jacket method.

The water jacket method volumetric expansion test can be carried out on equipment with a levelling burette or with a fixed burette or by weighing the mass of water displaced.

F.2 Test equipment

The following requirements are general to the methods of test:

a) hydraulic test pressure pipelines shall be capable of withstanding a pressure 1,5 times the maximum test pressure of any cylinder that will be tested;

b) glass burettes shall be of sufficient length to contain the full volumetric expansion of the cylinder and shall have bores of uniform diameter such that the expansion can be read to the nearest 1 % or 0,1 ml, whichever is the greater;

c) weighing scales shall be to a tolerance of 1 % or 0,1 g whichever is the greater;

d) pressure gauges shall be of the accuracy class 1 with a scale appropriate to the test pressure. They shall be tested at regular intervals in any case but not less frequently than once per month;

e) a suitable device shall be employed to ensure that no cylinder is subjected to a pressure in excess of its test pressure;

f) pipe work should utilise long bends in preference to elbow fittings and pressure pipes should be as short as possible. Flexible tubing should be capable of withstanding 1,5 times the maximum test pressure in the equipment and have sufficient wall thickness to prevent kinking;

g) all joints should be leak-tight;

h) when installing equipment, care should be taken to avoid trapping of air in the system.

F.3 Water jacket volumetric expansion test

F.3.1 General description

This method of test necessitates enclosing the water filled cylinder in a jacket also filled with water. The total and any permanent volumetric expansion of the cylinder are measured as the amount of water displaced by the expansion of the cylinder when under pressure and the amount of water displaced after the pressure has been released. The permanent expansion is calculated as a percentage of the total expansion. The water jacket should be fitted with a safety device capable of releasing the energy from any cylinder that can burst at test pressure.

It should be ensured that the entire external surface of the cylinder is wet without any bubbles.

An air bleed valve shall be fitted to the highest point of the jacket.

Two methods of performing this test are described in F.3.2 and F.3.3. Other methods are acceptable provided that they are capable of measuring the total, and, if any, the permanent volumetric expansion of the cylinder.

F.3.2 Water jacket volumetric expansion – Levelling burette method

The equipment should be installed as shown in Figure F.1.

Procedure

a) Fill the cylinder with water and attach it to the water jacket cover.

b) Seal the cylinder in the water jacket and fill the jacket with water, allowing air to bleed off through the air bleed valve.

c) Connect the cylinder to the pressure line. Adjust the burette to zero level by manipulation of the jacket filling valve and drain valve. Raise the pressure to 2/3 of the test pressure, stop pumping and close the hydraulic pressure line valve. Check that the burette reading remains constant.

d) Re-start the pump and open the hydraulic pressure line valve until the cylinder test pressure is reached. Close the hydraulic pressure line valve and stop pumping.

e) Lower the burette until the water level is at the zero mark on the burette support. Take a reading of the water level in the burette. This reading is the total expansion and shall be recorded on the test certificate.

f) Open the hydraulic line drain valve to release the pressure from the cylinder. Raise the burette until the water level is at the zero mark on the burette support. Check that pressure is at zero and that water level is constant.

g) Read the water level in the burette. This reading is the permanent expansion, if any, and shall be recorded on the test certificate.

h) Check that the permanent expansion as determined by the following equation:

$$\frac{\text{Permanent expansion}}{\text{Total expansion}} \times 100\ \% = \%\ \text{Permanent expansion}$$

does not exceed the percentage given in the design specification.

F.3.3 Water jacket volumetric expansion test — Fixed burette method

The equipment should be installed as shown in Figure F.2.

Procedure:

The procedure for this method of test is similar to that described in F.3.2 except that the burette is fixed.

a) Follow procedures F.3.2, a) and b).

b) Connect the cylinder to the pressure line.

c) Adjust the water level to a datum. Apply pressure until the test pressure is reached and record the burette reading. The reading above the datum is the total expansion, and shall be recorded on the test certificate.

d) Release the pressure and record the burette reading. The reading above the datum is the permanent expansion and shall be recorded on the test certificate.

e) Check that the permanent volumetric expansion as determined by the following equation:

$$\frac{\text{Permanent expansion}}{\text{Total expansion}} \times 100\,\% = \%\ \text{Permanent expansion}$$

does not exceed the percentage given in the design specification.

F.4 Non-water jacket volumetric expansion test

F.4.1 General description

This method consists of measuring the amount of water passed into the cylinder under proof pressure, and on release of this pressure, measuring the water returned to the manometer. It is necessary to allow for the compressibility of water, and the volume of the cylinder under test to obtain true volumetric expansion. No fall in pressure under this test is permitted.

The water used should be clean and free of dissolved air. Any leakage from the system or the presence of free or dissolved air will result in false readings.

The equipment should be installed as shown in Figure F.3. This figure illustrates diagrammatically the different parts of the apparatus. The water supply pipe should be connected to an overhead tank as shown, or to some other supply giving a sufficient head of water.

F.4.2 Requirement for testing

The apparatus shall be arranged such that all air can be removed and that accurate readings can be determined of the volume of water required to pressurise the filled cylinder and of the volume expelled from the cylinder when depressurised. In the case of larger cylinders, it can be necessary to augment the glass tube with metal tubes arranged in the manifold.

If a single acting hydraulic pump is used, care shall be taken to ensure that the piston is in the back position when the water levels are noted.

F.4.3 Test method

a) Completely fill the cylinder with water and determine the weight of water required.

b) Connect the cylinder to the hydraulic test pump through the coil and check that all valves are closed.

c) Fill the pump and system with water from tank 1 by opening valves 7, 10 and 11.

d) To ensure the expulsion of air from the system, close the air-bleed and bypass valves and raise the system pressure to approximately one-third of the test pressure. Open the bleed valve to release the trapped air by reducing the system pressure to zero, and reclose the valve. Repeat if necessary.

e) Continue to fill the system until the level in the glass manometer is approximately 300 mm from the top. Close the make-up valve and mark the water level with a pointer, leaving the isolating and air-bleed valves open. Record the level.

f) Close the air bleed valve. Raise the pressure in the system until the pressure gauge records the required test pressure. Stop the pump and close the hydraulic line valve. After approximately 30 s there shall be no change in either the water level or the pressure. A change in level indicates leakage. A fall in pressure, if there is no leakage, indicates that the cylinder is still expanding under pressure.

g) Record the fall in water level in the glass tube. (Provided that there has been no leakage, all the water drained from the glass tube will have been pumped into the cylinder to achieve the test pressure.) The difference in water level is the total volumetric expansion.

h) Open the hydraulic main and bypass valves slowly to release the pressure in the cylinder and allow the water so released to return to the glass tube. The water level should return to the original level marked by the pointer. Any difference in level will denote the amount of permanent volumetric expansion in the cylinder, neglecting the effect of the compressibility of the water at the test pressure. The true permanent volumetric expansion of the cylinder is obtained by correcting for the compressibility of the water which is given by the equation in F.4.5.

i) Before disconnecting the cylinder from the test rig, close the isolating valve. This will leave the pump and system full of water for the next test. Action d) shall, however, be repeated at each subsequent test.

j) If permanent volumetric expansion has occurred, record the temperature of the water in the cylinder.

F.4.4 Test results

a) The tests determine the volume of water required to pressurize the filled cylinder to the test pressure

b) The total mass and temperature of water in the cylinder are known, enabling the change in volume of the water in the cylinder owing to its compressibility to be calculated. The volume of water expelled from the cylinder when depressurized is known. Thus the total volumetric expansion and the permanent volumetric expansion can be determined.

c) The permanent volumetric expansion shall not exceed the percentage given in the design specification.

F.4.5 Calculation of compressibility of water

The equation used for calculating the reduction in volume of water due to its compressibility is as follows:

$$C = WP \cdot \left(K - \frac{0{,}68P}{10^5} \right)$$

where

C is the reduction in volume of water due to its compressibility, in cm^3

W is the mass of water in kg

P is the pressure in bar

K is the compressibility factor for individual temperature as listed in Table F.1.

Table F.1 — Compressibility factor, *K*

Temperature °C	*K*	Temperature °C	*K*	Temperature °C	*K*
6	0,049 15	13	0,047 59	20	0,046 54
7	0,048 86	14	0,047 42	21	0,046 43
8	0,048 60	15	0,047 25	22	0,046 33
9	0,048 34	16	0,047 10	23	0,046 23
10	0,048 12	17	0,046 95	24	0,046 12
11	0,047 92	18	0,046 80	25	0,046 04
12	0,047 75	19	0,046 68	26	0,045 94

F.4.6 Example calculation

In the following example calculation, allowance for pipe stretch has been neglected.

EXAMPLE:

Test pressure	= 232 bar
Mass of water in cylinder at zero gauge pressure	= 113,8 kg
Temperature of water	= 15 °C
Water forced into cylinder to raise pressure to 232 bar	= 1 745 cm^3 (or 1,745 kg)
Total mass of water in cylinder at 232 bar	= 113,8 kg + 1,745 kg = 115,545 kg
Water expelled from cylinder to depressurise	= 1 742 cm^3
Permanent expansion = 1745 cm^3 – 1742 cm^3	= 3 cm^3

From Table F.1 factor for 15 °C = 0,0472 5

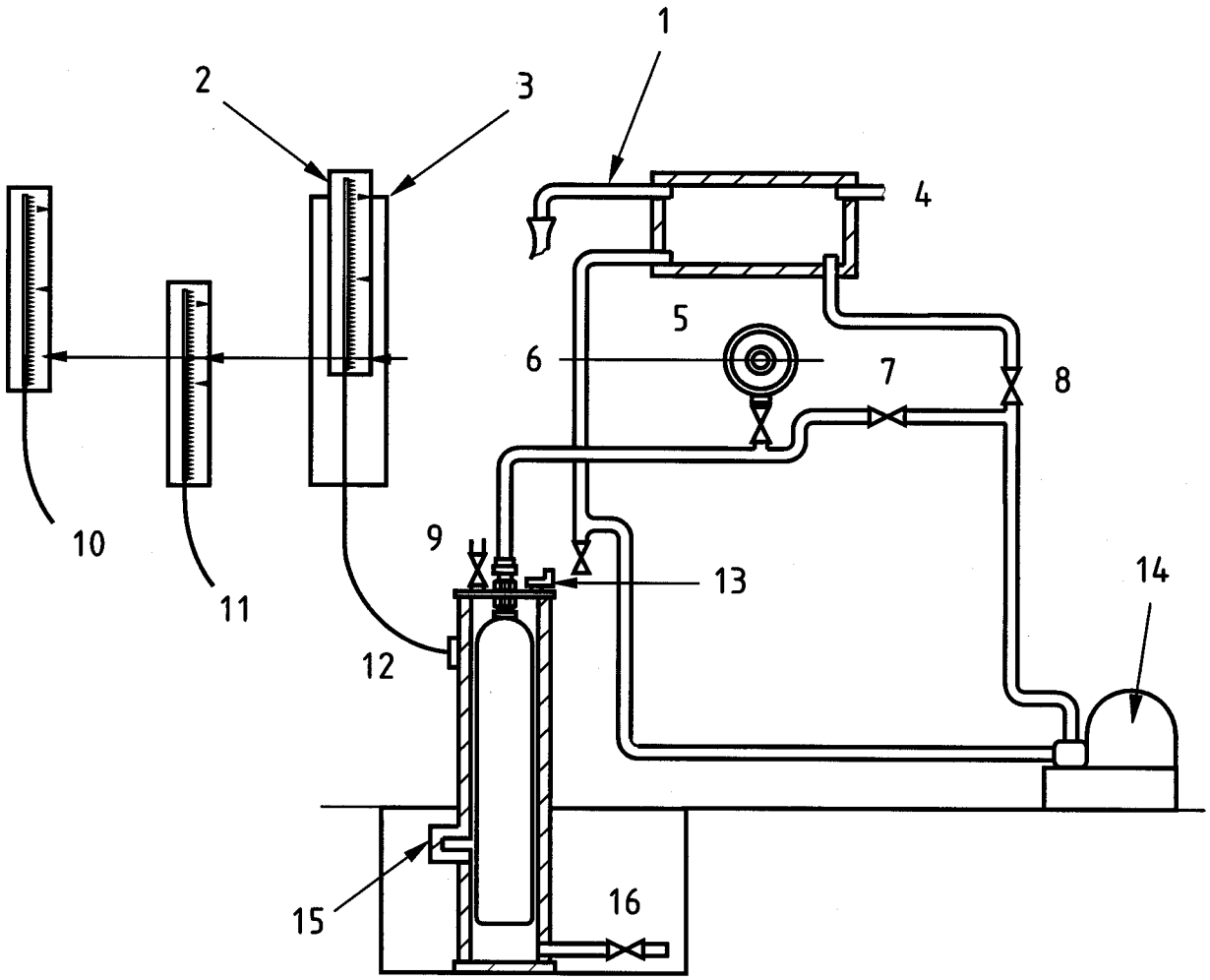
$$C = WP \cdot \left(K - \frac{0{,}68P}{10^5} \right)$$

$$= 115{,}545 \cdot 232 \cdot \left(0{,}04725 - \frac{0{,}68 \cdot 232}{10^5} \right)$$

$$= \quad 1224{,}314 \text{ cm}^3$$

Total volumetric expansion = 1 745 cm^3 – 1 224,31 cm^3 = 520,686 cm^3

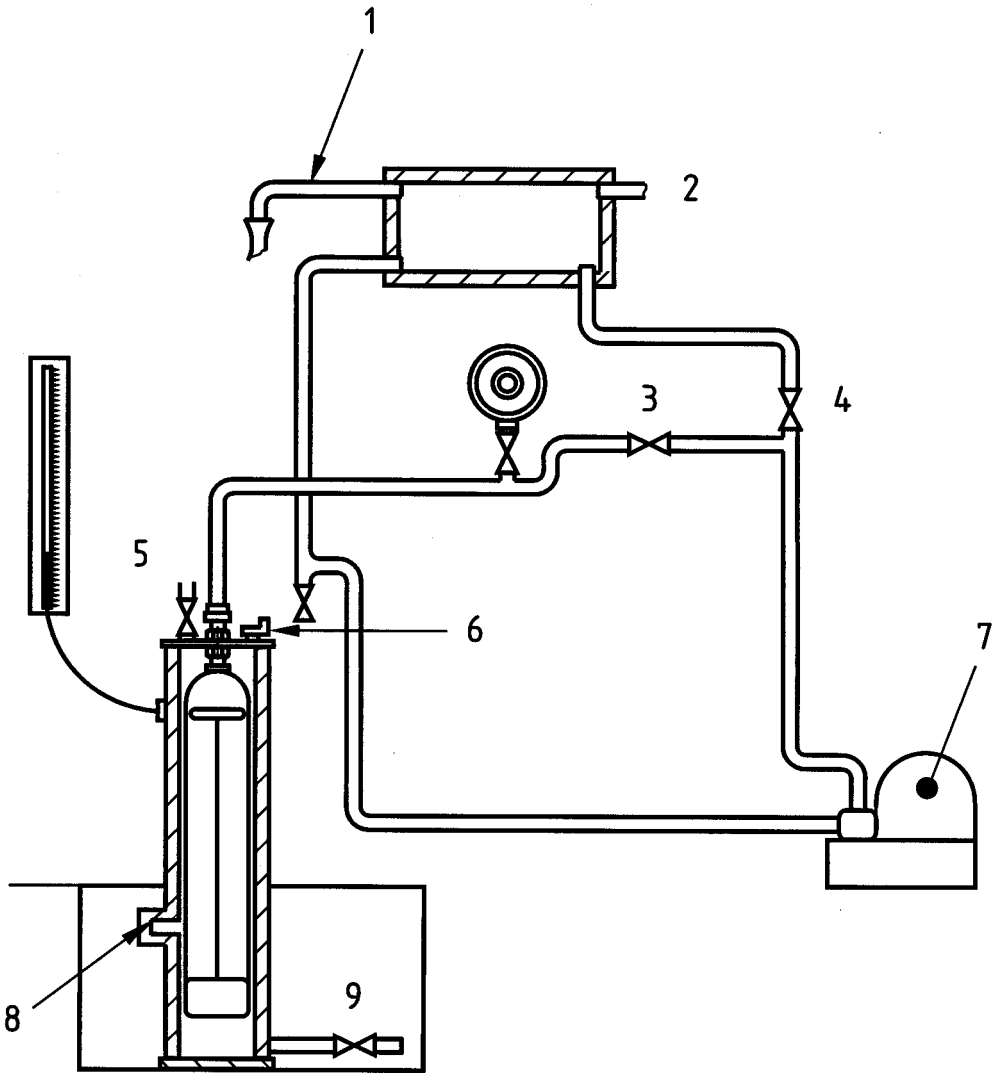
Permanent expansion % = $\frac{3 \cdot 100}{520{,}686}$ = 0,58 %



Key

1 Overflow
2 Calibrated burette sliding in fixed frame
3 Fixed frame
4 Water supply
5 Water and eye level
6 Pointer attached to fixed frame at water level
7 Hydraulic line valve
8 Priming valve
9 Jacket filling valve
10 Position when pressure is released - Reading = permanent expansion
11 Position at test pressure - Reading = total expansion
12 Position before pressurization
13 Air bleed valve
14 Pump
15 Relief device
16 Drain

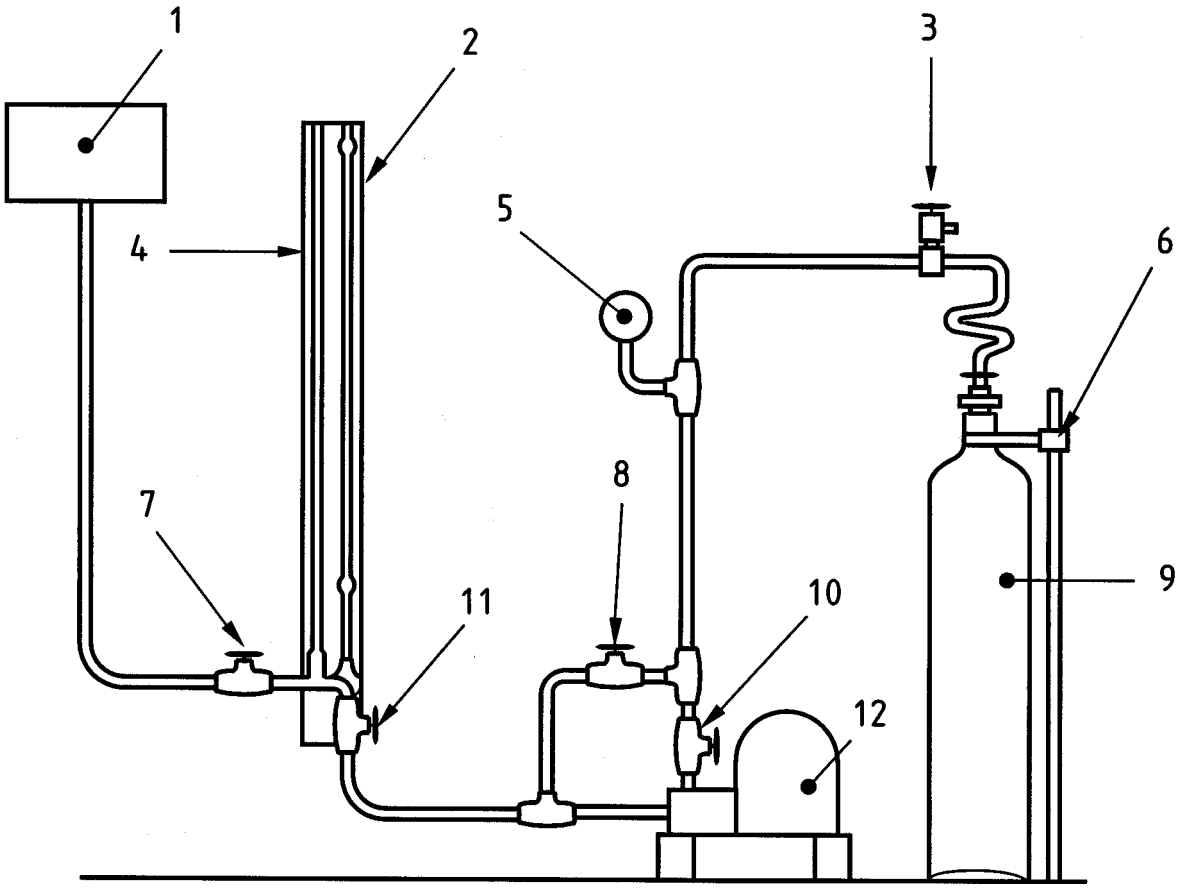
Figure F.1 — Water jacket volumetric expansion test (levelling burette method)



Key

1 Overflow
2 Water supply
3 Hydraulic line valve
4 Priming valve
5 Jacket filling valve
6 Air bleed valve
7 Pump
8 Relief device
9 Drain

Figure F.2 — Water jacket volumetric expansion test (fixed burette method)



Key

1 Supply tank
2 Calibrated glass burette
3 Air bleed valve
4 Adjustable pointer
5 Main pressure gauge
6 Cylinder to be supported
7 Make-up valve
8 Bypass valve
9 Test cylinder
10 Hydraulic pressure line valve
11 Pump suction isolating valve
12 Pump

Figure F.3 — Non-water jacket method: diagrammatic layout of container testing apparatus

Annex G
(normative)

Ultrasonic test

G.1 Scope

This annex specifies the ultrasonic testing (UT) of seamless gas cylinders of water capacity ≥ 2 L, within the framework of periodic inspections. With the agreement of the competent person the pressure test as described in clause 10 may be replaced by an ultrasonic test.

The test on gas cylinders as described below is based on the ultrasonic testing of pipes to ISO 9305, ISO 9764 and ISO 10543. The special geometrical features of compressed gas cylinders and the boundary conditions for periodic inspections have been taken into account.

G.2 Requirements

G.2.1 General

The cylindrical part of the cylinder, the transition to the shoulder, the transition at the base and critical zones of the base shall be tested ultrasonically. This shall be carried out using a mechanised test device (see Figure G.1). Where such a testing device is unable to carry out this inspection outside the cylindrical part, a supplementary manual examination shall be performed.

Cylinders which are suspected of fire or heat damage shall not be examined ultrasonically.

G.2.2 Testing equipment

The installation shall have at least 5 ultrasonic probes suitably arranged (e.g. see Figure G.2) to scan the whole surface of the cylindrical part of the cylinder, including the adjacent transitions to the base and shoulder.

The arrangement described above is an example. Other arrangements can be possible provided that the probes are such that any longitudinal or transverse defect detected can be located from two opposing sides.

The pulse echo method shall be used to detect defects and measure wall thickness ultrasonically. The testing techniques used may either be the contact or the immersion type (see Figure G.3).

The cylinder wall shall be tested using UT probes (shear wave, angle of refraction about 45 °), diameter of probe less than 15 mm, operating with a frequency of 2 MHz to 10 MHz. The examination shall cover longitudinal defects in both circumferential directions (clockwise and anti-clockwise) and transverse defects in both longitudinal directions (forward and backward).

The wall thickness measurement shall be performed using a normal probe (angle of refraction 0 °), diameter of probe less than 15 mm operating with a frequency of 2 MHz to 10 MHz. The tolerance of the wall thickness measurement shall lie in the range of ± 0,1 mm.

The cylinders to be tested and the search unit with the probes shall go through a rotating motion and translation relative to one another such that a helical scan is performed on the cylinder. The speeds of translation and rotation shall be constant within ± 10 % (see also G.4.1).

The ultrasonic test unit shall have a screen. The installation shall have an automatic alarm level for each probe which gives an automatic acoustic and visual signal when a fault signal (defect or below-minimum wall thickness) is registered. A distinction in the alarm level between internal and external defect signal from a probe is desirable, but not necessary (see Figure G.5.1).

The equipment shall be serviced regularly at least in accordance with the equipment manufacturer's recommendations to ensure that its accuracy is maintained. Inspection records shall be kept.

G.2.3 Manual ultrasonic unit

The requirements laid down in G.2.2 shall apply as appropriate for the selection of the probes and servicing of the unit.

G.2.4 Cylinders

The outer and inner surfaces of any cylinder to be tested ultrasonically shall be in a suitable condition for an accurate and reproducible test. In particular the external surface shall be free of rust, loose paint, dirt and oil. An ultrasonic test is only valid when the noise signals caused by the surface are at least 50 % below the corresponding reference signal.

G.2.5 Personnel

The test equipment shall be operated and its operation supervised by qualified and experienced personnel only. The tester shall be certified to EN 473 level 1 for ultrasonic testing. The testing organisation shall have a supervisor qualified to at least EN 473 level 2 for ultrasonic testing.

G.3 Calibration

G.3.1 General

For calibrating the UT defect testing and wall thickness measurement, a calibration specimen with notches shall be used. A specimen of convenient length shall be prepared from a cylinder corresponding to the diameter, wall thickness, external surface finish and material (same range of chemical composition and mechanical properties) of the cylinder to be tested.

G.3.2 Defect detection

For manual and mechanised defect testing purposes, four rectangular notches are required as reference notches in the calibration specimen (see Figure G.4):

- inner notch in longitudinal direction;
- inner notch in transverse direction;
- outer notch in longitudinal direction;
- outer notch in transverse direction;

with the following dimensions in each case:

- length L: 50 mm;
- depth D: (5 ± 0,75) % of nominal wall thickness S;
- width W: ≤ 2 D.

The notches may be produced either by means of electrical erosion or sawing. The bottom corners of the notch may be rounded. The notches shall be located such that there is no interference from any other defect in the reference standard. The shape and dimensions of the reference standard shall be verified.

For the first step during the calibration procedure the ultrasonic testing equipment shall be adjusted in such a way that under test conditions an alarm signal is given when the UT echoes from the reference notches exceed the alarm level (see Figure G.5 a)). This sensitivity is the basic sensitivity.

During the second step of the calibration procedure the basic sensitivity shall be changed to a testing sensitivity:

a) For testing gas cylinders (except those in category c) below) the ultrasonic sensitivity shall be lowered from the basic sensitivity by 2 dB (see Figure G.5 b));

b) For steel cylinders in hydrogen service the sensitivity as per a) above shall only be used if the cylinder has already been ultrasonically examined and verified as being suitable for hydrogen service. For other hydrogen cylinders see c) below;

c) For testing gas cylinders where the gas service can produce conditions under which stress corrosion cracking can occur, the ultrasonic sensitivity shall be increased by at least 6 dB above the basic sensitivity (see Figure G.5 b)).

G.3.3 Wall thickness

To calibrate the manual and mechanised wall thickness measurement, an area on the calibration specimen shall be used, of which the exact wall thickness is known.

The minimum wall thickness of the gas cylinder defined in the type approval is set as the alarm level in the evaluation unit of the ultrasonic wall thickness measuring device.

G.3.4 Time of calibration

The UT equipment shall be calibrated at least at the beginning and at the end of each shift. If, during the check, the presence of the respective reference notch is not detected, all cylinders tested subsequently to the last acceptable check shall be re-tested after the equipment has been re-calibrated.

G.4 Performance of the test

G.4.1 Defect detection in cylindrical part by mechanized installation

The cylindrical part of the cylinder and the transitions to the shoulder and to the base shall be tested for longitudinal and transverse defects using a mechanised testing device.

The rotational speed of the cylinder and the pulse repetition frequency of the probes shall be mutually adjusted in such a way that the displacement distance of each probe in the circumferential direction between two successive test pulses is less than 1 mm.

The rotational and axial speed used during the test shall be mutually adjusted in such a way that the pitch of the helix is less than the diameter of one probe (at least a 10 % overlap shall be guaranteed) and relates to the effective beam so as to ensure 100 % coverage.

G.4.2 Defect detection in cylinder ends by manual testing

The critical areas of the ends, especially the transition zone of concave bases, shall be carefully checked. The extent of the test depends on the type of base, the position of the critical zones, the form of possible defects, the accessibility of the test surface (in the case of foot rings) and the roughness of the external surface. Figure G.6 shows how the test can be conducted for the above-mentioned conditions.

G.4.3 Wall thickness measurement by mechanised installation

100 % of the cylindrical part shall be examined with a normal probe.

G.4.4 Wall thickness measurement by manual testing

The transition area to the base and the base itself shall be examined with a normal ultrasonic probe, if not already performed using mechanical devices.

G.5 Interpretation of results

Gas cylinders tested to the testing sensitivity in accordance with G.3.2 and G.3.3 where no defect signal above the alarm level has been recorded have passed the test. Where a defect signal above the alarm level (defect or below minimum wall thickness) has been recorded (see Figure G.7) the cylinder shall be re-evaluated with respect to the defect rejection limits in accordance with annex C.

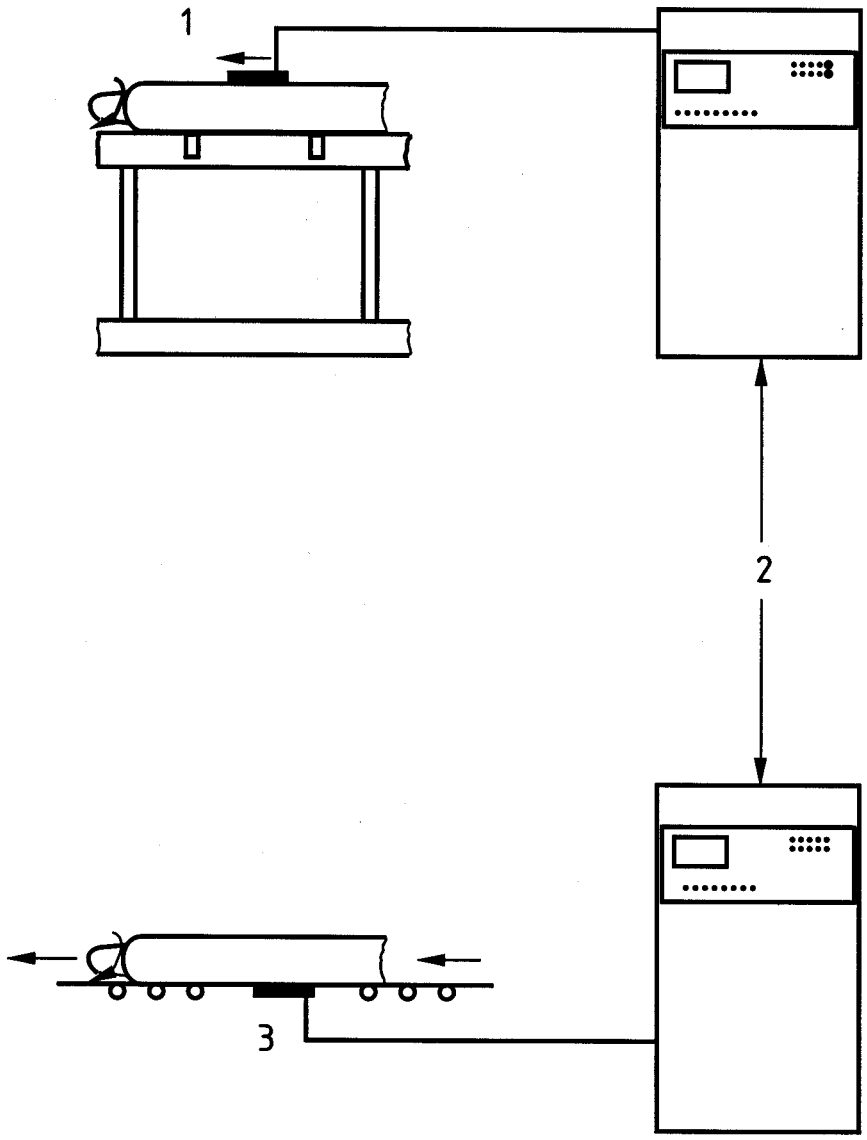
G.6 Records

In addition to the required record according to 12.7, the following information shall be recorded:

a) identification of ultrasonic equipment used;

b) an ultrasonic test symbol e.g. UT;

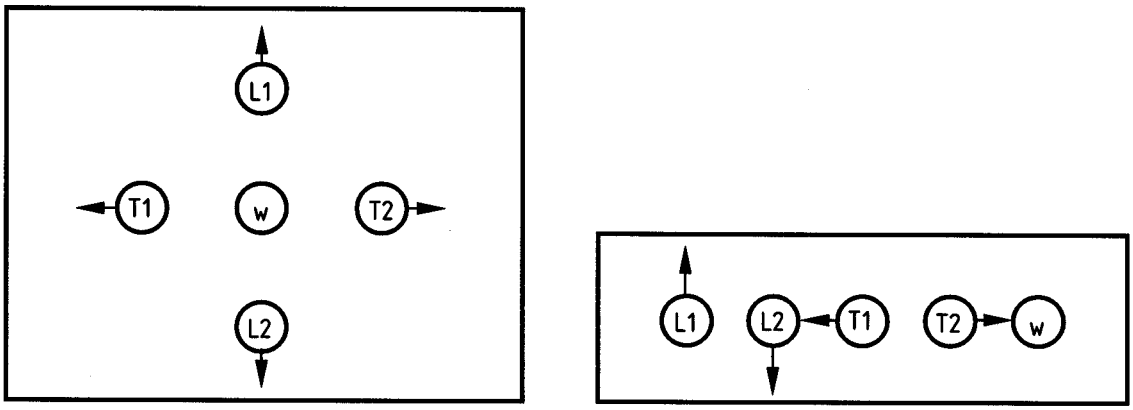
c) the results of examination. If a re-evaluation according to annex C has been necessary following detection of a defect, the basis of re-evaluation shall be recorded.



Key

1 UT probes moving
2 Ultrasonic test equipment
3 Cylinder moving

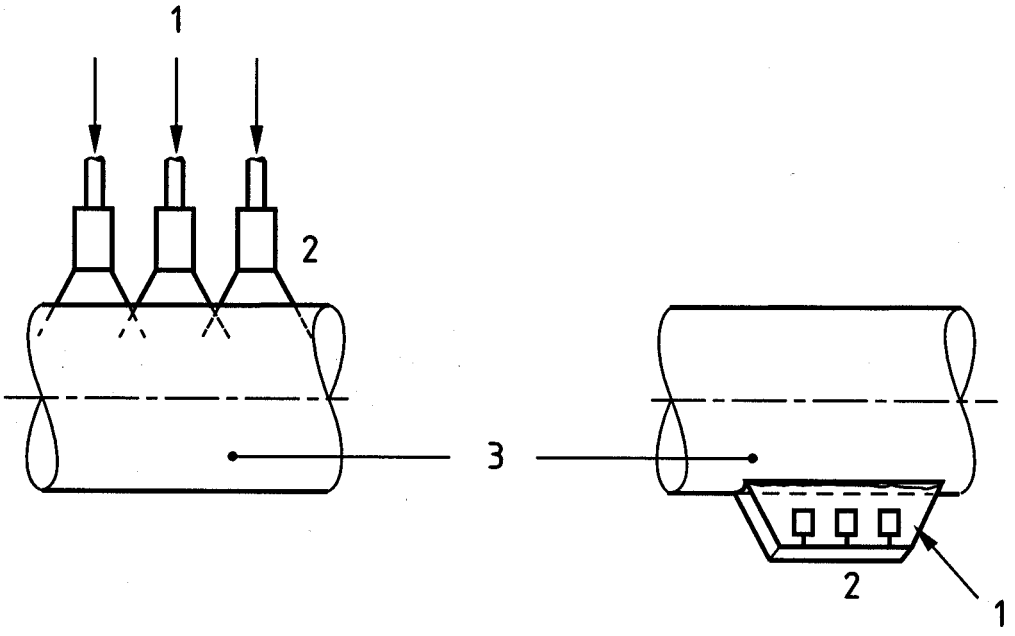
Figure G.1 — Two types of ultrasonic test devices for gas cylinders (schematic)



Key

L1, L2	Longitudinal probes
T1, T2	Transverse probes
w	Wall thickness probe

Figure G.2 — Arrangement of probes (examples)

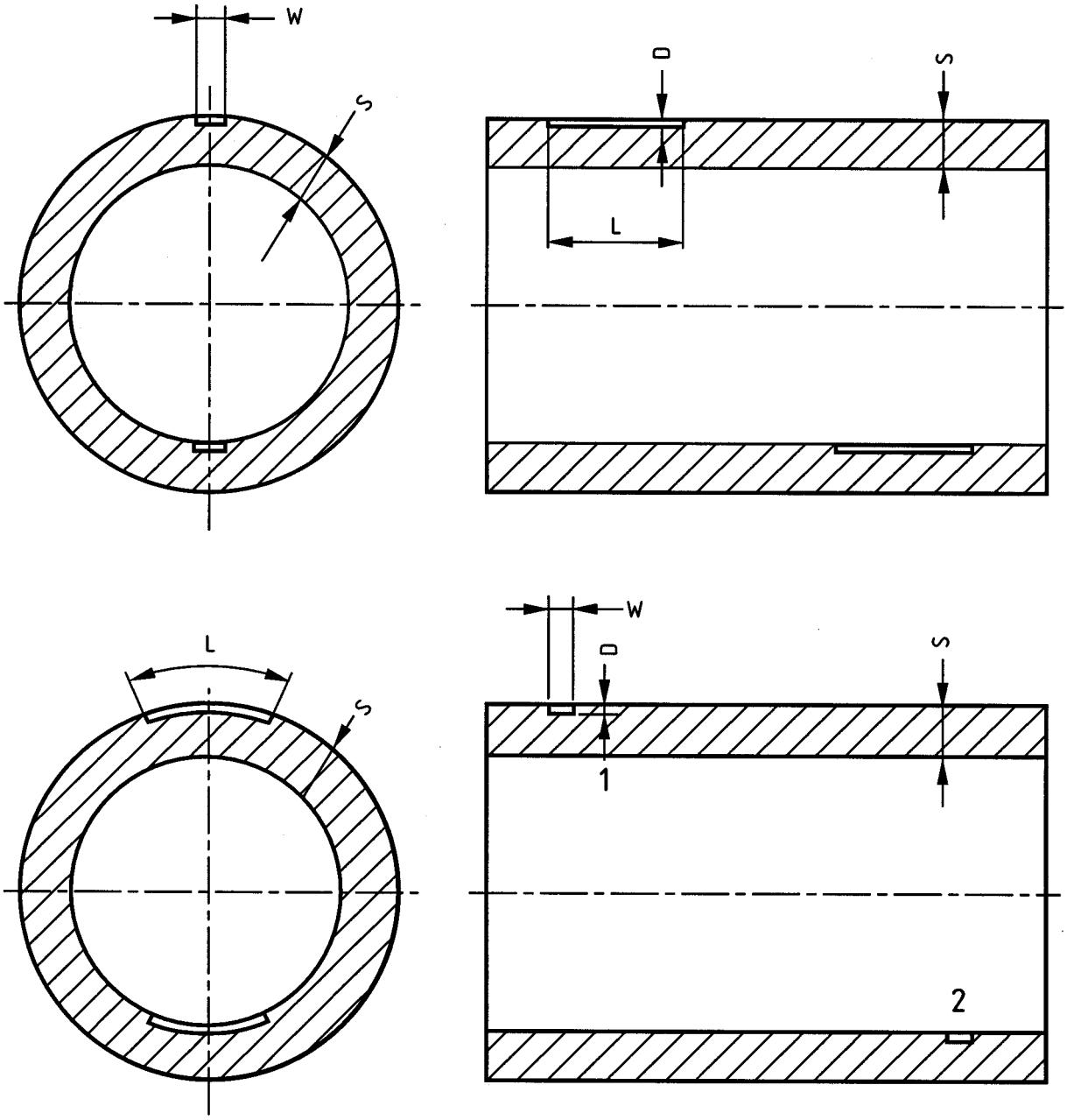


a) Contact type b) Immersion type

Key

1 Water
2 Probes
3 Cylinder

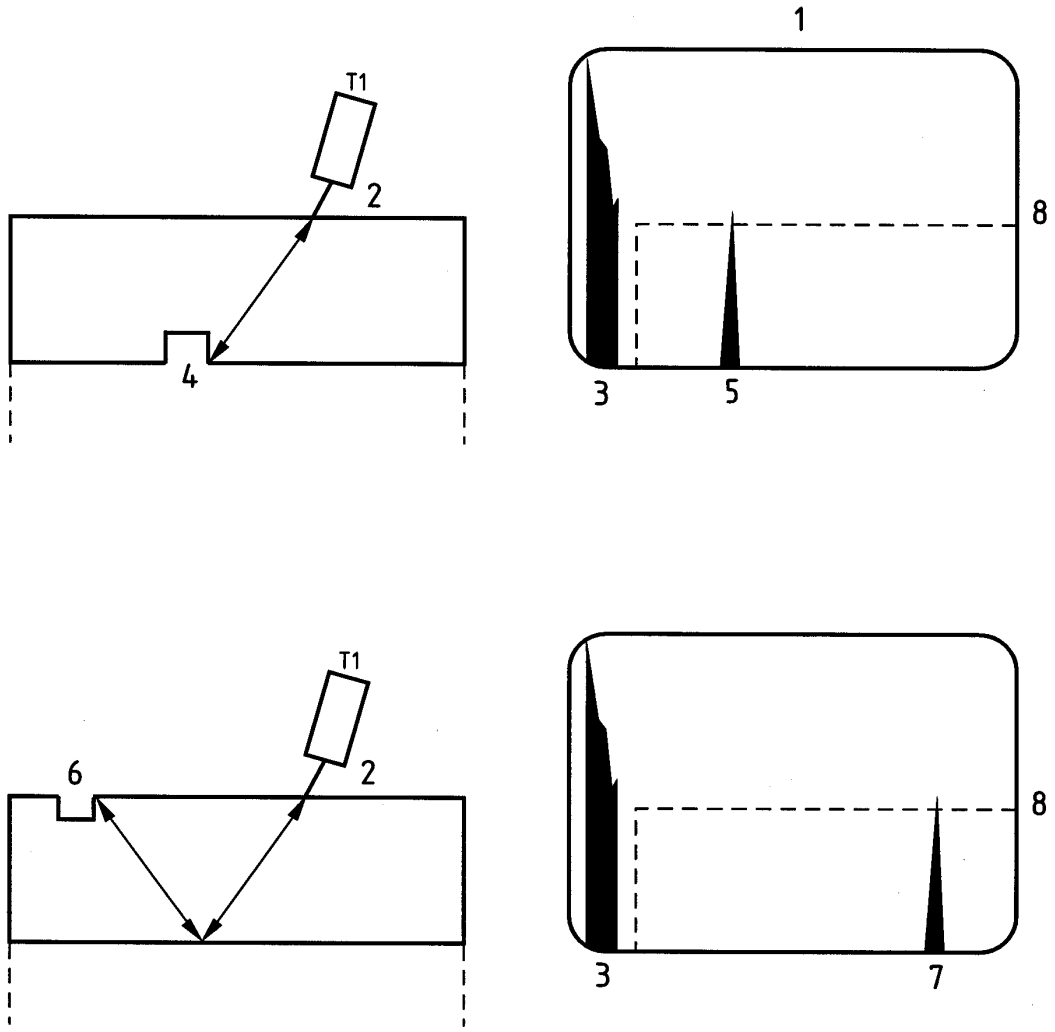
Figure G.3 — Coupling techniques



Key

1 Outer notch
2 Inner notch
L Length of the notches: 50 mm
D Depth of the notches: (5 ± 0,75) % *S*
W Width of the notches: ≤ 2*D*
S Nominal wall thickness

Figure G.4 — Reference standards according to G.3.2



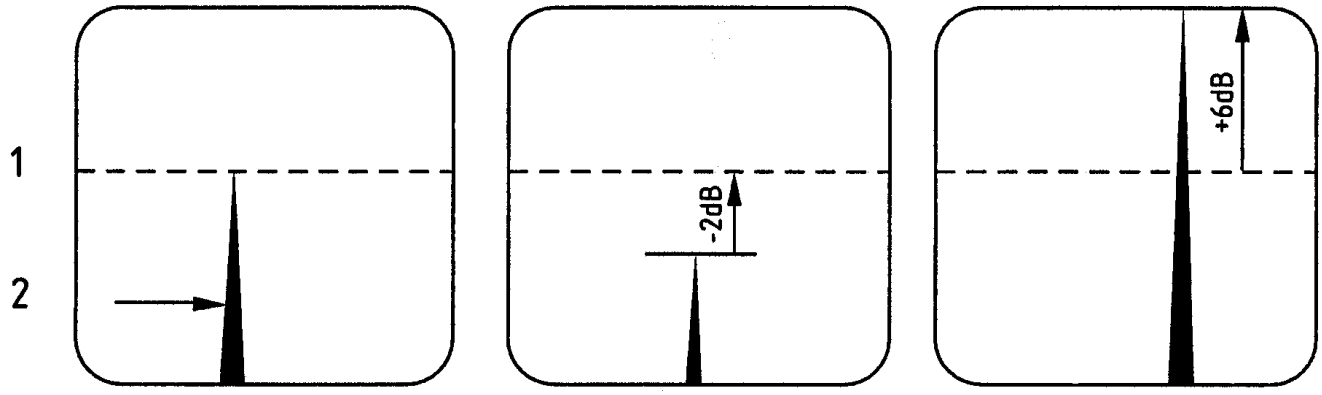
a) Calibration specimen – Inner reference notch in transverse direction

b) Calibration specimen – Outer reference notch in transverse direction

Key

1 Screen
2 Calibration specimen wall
3 UT signal trace from calibration specimen wall
4 Inner reference notch
5 UT signal trace from inner reference notch
6 Outer reference notch
7 UT signal trace from outer reference notch
8 Alarm level

Figure G.5 a) — Calibration procedure, step 1: Testing of basic sensitivity



a) Basic sensitivity in accordance with G.3.2

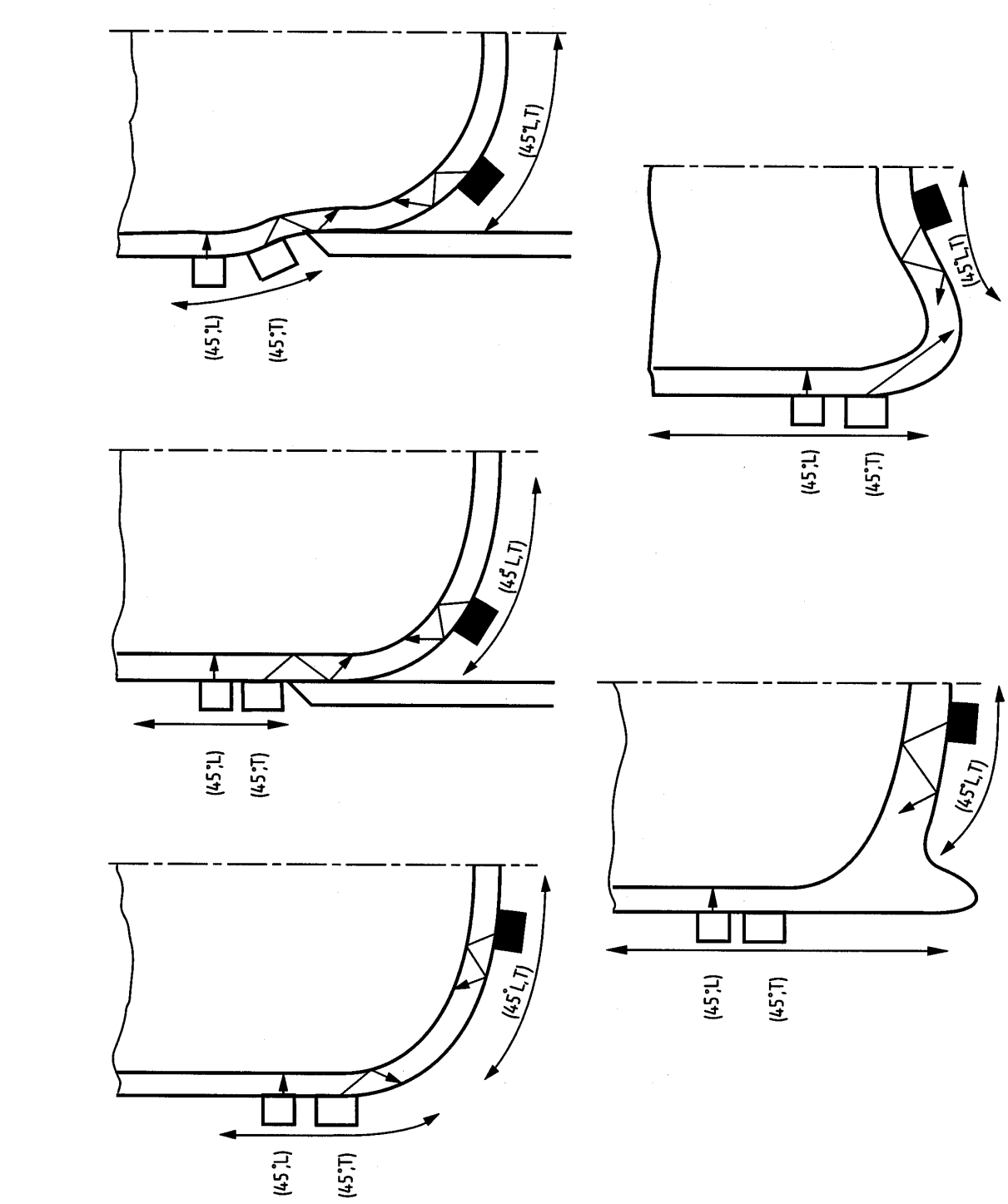
b) Testing sensitivity in accordance with G.3.2 a) and b)

c) Testing sensitivity in accordance with G.3.2 c)

Key

1 Alarm level
2 Signal of reference notch

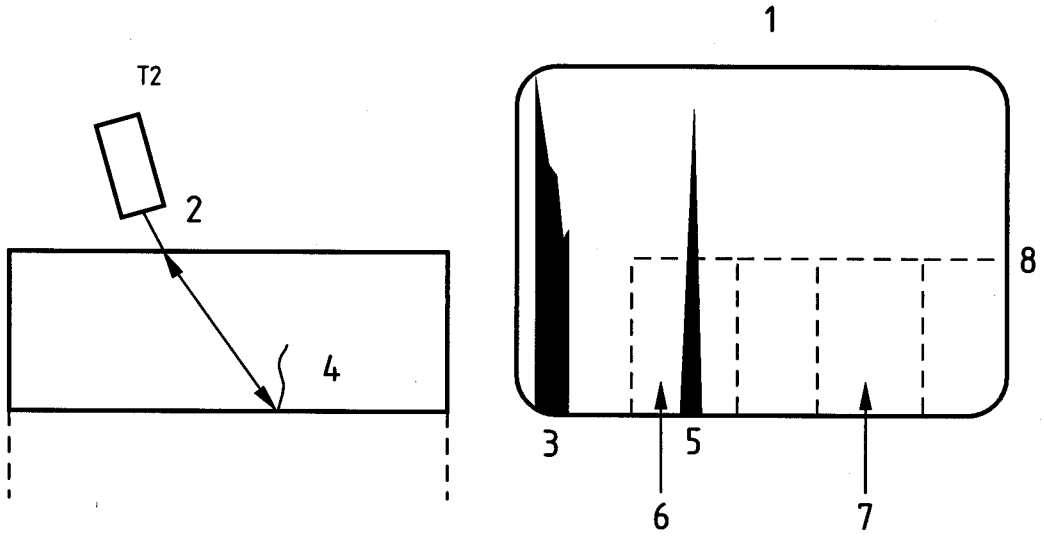
Figure G.5 b) — Calibration procedure, step 2: Establishment of sensitivity of control



Key

L longitudinal of the base shape
T transverse of the base shape
■ = manual (common practice)
□ = mechanized (common practice)

Figure G.6 — Defect detection



Key

1 Screen
2 Cylinder wall
3 UT signal from cylinder wall
4 Crack on internal surface
5 UT signal from crack
6 Region of signals from cracks on internal surface
7 Region of signals from cracks on external surface
8 Alarm level

Figure G.7 — Detection of crack in transverse direction (example)

Annex H
(informative)

Inspection and maintenance of valves and their connections: recommended procedures

Check all threads to ensure the thread diameters, form, length, and taper are satisfactory.

If threads show signs of distortion, deformation, or burring, rectify these faults. Excessive thread damage or serious deformation of the valve body, hand wheel, spindle or other components is cause for replacement.

Maintenance of the valve includes general cleaning together with replacement of elastomers and worn or damaged components, packing and safety devices, where necessary.

Where the use of lubricants/elastomers is permitted, use only those approved for the gas service, particularly oxidising gas service.

After the valve has been re-assembled check for leakage and correct operation.

This can be done prior to the valve being refitted to the cylinder, or during and after the first gas charge subsequent to the inspection and test of the cylinder.

NOTE More detailed information on valve maintenance is included in the following standard, currently in preparation:

"*Transportable gas cylinders — Inspection and maintenance of cylinder valves at time of periodic inspection of gas cylinders*" (prEN 14189)

Annex I
(informative)

List of commonly used gases corrosive to cylinder material

Gas name	Chemical equation	ADR classification
Borontrichloride	BCl_3	2 TC
Borontrifluoride	BF_3	1 TC
Chlorine	Cl_2	2 TC
Dichlorosilane	SiH_2Cl_2	2 TFC
Fluorine	F_2	1 TOC
Hydrogen bromide	HBr	2 TC
Hydrogen chloride	HCl	2 TC
Hydrogen cyanide	HCN	class 6.1
Hydrogen fluoride	HF	class 8
Hydrogen iodide	HI	2 TC
Methylbromide	CH_3Br(R40B1)	2 T
Nitric oxide	NO	1 TOC
Nitrogen dioxide	N_2O_4	2 TOC
Phosgene	$COCl_2$	2 TC
Silicon tetrachloride	$SiCl_4$	class 8
Silicon tetrafluoride	SiF_4	1 TC
Sulphur tetrafluoride	SF_4	2 TC
Trichlorosilane	$SiHCl_3$	class 4.3
Tungsten hexafluoride	WF_6	2 TC
Vinyl bromide	CH_2:CHBr (R1140B1)	2 F
Vinyl chloride	CH_2:CHCl (R1140)	2 F
Vinyl fluoride	CH2:CHF (R1141)	2 F
NOTE 1 These gases in a pure form, are recognized to be potentially corrosive to low alloy steels in EN ISO 11114-1 (see groups 4, 6, 8,9, 10 and 11).		
NOTE 2 Mixtures containing these gases are considered as not corrosive.		

Bibliography

EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles.*

EN 849, *Transportable gas cylinders — Cylinder valves — Specification and type testing.*

EN 1089-2, *Tranpsortable gas cylinders — Gas cylinder identification (excluding LPG) — Part 2: Precautionary labels.*

EN 1089-3, *Transportable gas cylinders — Gas cylinder identification — Part 3: Colour coding*.

ISO 6506, *Metallic materials — Hardness test — Brinell test*.

ISO 9303, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections.*

ISO 9305, *Seamless steel tube for pressure purposes — Full peripheral ultrasonic testing for the detection of transverse imperfections.*

ISO 9764, *Electrical resistance and induction welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal imperfections.*

ISO 10543, *Seamless and hot stretch-reduced welded steel tubes for pressure purposes — Full peripheral ultrasonic thickness testing.*

Council Directive 1999/36/EC of 29 April 1999 on transportable pressure equipment (TPED)

84/525/EEC Council Directive of 17 September 1984 on the approximation of the laws of the Member States relating to seamless, steel gas cylinders

ADR European agreement on the International Carriage of Dangerous Goods by Road

RID Regulations concerning the International Carriage of Dangerous Goods by Rail

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