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Transportable gas cylinders — Periodic inspection and testing of composite gas cylinders

Bouteilles à gaz transportables — Contrôles et essais périodiques des bouteilles à gaz en matériau composite

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11623 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

Annexes B and ZA form a normative part of this International Standard. Annexes A, C and D are for information only.

Annex ZA provides a list of corresponding International and European Standards for which equivalents are not given in the text.

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Foreword

This document (EN ISO 11623:2002) has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI, in collaboration with Technical Committee ISO/TC 58 "Gas cylinders".

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 September 2002, and conflicting national standards shall be withdrawn at the latest by September 2002.

This European Standard has been submitted for reference into the RID and/or 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.

Annexes A, C and D are informative.

Annexes B and ZA are normative.

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.

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Introduction

The principal aim of periodic inspection and testing is that at the completion of the test the cylinders may be reintroduced into service for a further period of time. It is not possible to identify all considerations for inspecting and re-testing of composite cylinders in this publication. Questions regarding specific cylinders should be directed to the manufacturer.

1 Scope

This standard specifies the requirements for periodic inspection and testing of hoop wrapped and fully wrapped composite transportable gas cylinders, with aluminium, steel or non-metallic liners or of linerless construction, intended for compressed, liquefied or dissolved gases under pressure, of water capacity from 0,5 l up to 450 l.

NOTE As far as practicable, this standard may also be applied to cylinders of less than 0,5 l water capacity.

This standard specifies the requirements for periodic inspection and testing to verify the integrity of such gas cylinders for further service.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places 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 629-2:1996, *Transportable gas cylinders - 25E taper thread for connection of valves to gas cylinders - Part 2: Gauge inspection*

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

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

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

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

prEN 1802, *Transportable Gas cylinders — Periodic inspection and testing of seamless aluminium alloy gas cylinders*

prEN 1968, *Transportable gas cylinders — Periodic inspection and testing of seamless steel gas cylinders*

prEN 13096, *Transportable gas cylinders — Filling conditions for single gases*

ISO 32:1977, *Gas cylinders for medical use — Marking for identification of content*

ISO 6406: 1992, *Periodic inspection and testing of seamless steel gas cylinders*

ISO 7225:1994, *Gas cylinders — Precautionary labels*

ISO 10461: 1993, *Seamless aluminium-alloy gas cylinders; periodic inspection and testing*

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

ISO 11114-2:1997, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

ISO 11191:1997, *Gas cylinders — 25E taper thread for connection of valves to gas cylinders — Inspection gauges*

ISO 11621: 1997, *Gas cylinders — Procedures for change of gas service*

ISO 13341:1997, *Transportable gas cylinders — Fitting of valves to gas cylinders*

ISO 10298, *Determination of toxicity of a gas or gas mixture*

ISO 13769, *Gas cylinders — Stamp marking*

3 Terms and definitions

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

3.1

burst pressure

maximum pressure attained during a burst test

3.2

composite overwrap

fibres and matrix taken together as a combined unit

3.3

exterior coating

layer of material applied to the cylinder as a protective coating or for cosmetic purposes

NOTE Not all composite cylinders will have a special exterior coating.

3.4

fibre

load-carrying part of the composite overwrap e.g. glass, aramid and carbon

3.5

fully wrapped composite cylinder without liner

cylinder manufactured only from continuous fibre strands in a resin matrix wrapped in both circumferential and longitudinal directions

3.6

fully wrapped composite cylinder with liner

steel, aluminium alloy or non-metallic liner wrapped with continuous fibre strands in a resin matrix both circumferentially and longitudinally

3.7

hoop wrapped composite cylinder

seamless steel or aluminium alloy liner wrapped with continuous fibre strands or steel wire around only the cylindrical body of the liner, leaving the metal in the neck and base regions exposed. The fibre strands are embedded in a resin matrix

3.8

identification label

label containing the permanent markings required by the relevant design document and EN 1089-1 or ISO 13769

3.9

LC₅₀

50 % lethal concentration, as defined in ISO 10298

3.10**lifetime**

service life of the cylinder, if specified on the design drawing

3.11**liner**

inner portion of the composite cylinder designed both to contain the gas and transmit the gas pressure to the composite overwrap. For hoop wrapped cylinders this provides a substantial structural strength.

3.12**non-metallic liner**

liner made from thermoplastic, thermosetting, or elastomer material

3.13**protective sleeve**

removable transparent or non-transparent sleeve fitted to the outside surface of the cylinder

3.14**repair**

minor refurbishment performed by competent persons under controlled conditions as described in 7.4, e.g. repair of resin matrix

3.15**resin matrix**

material which is used to bind and hold the fibres in place. It is usually a thermoplastic or thermosetting resin

3.16**rejected cylinder**

cylinder not fit for service in its present condition

3.17**toxic gases**

when $LC_{50} > 200$ p.p.m. V/V but $\leq 5\,000$ p.p.m. V/V, in accordance with ISO 10298

3.18**very toxic gases**

when $LC_{50} \leq 200$ p.p.m. V/V, in accordance with ISO 10298

4 Intervals between periodic inspection and testing

A cylinder shall fall due for periodic inspection and test on its first receipt by a filler after the expiry of the interval in Tables 1 to 4. However, a shorter period than that in Tables 1 to 4 may be stipulated by the inspection body for the first re-test only.

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. When the lifetime has expired, the cylinder shall not be refilled and shall be removed from service when presented for the next filling (see clause 13).

In the case of cylinders used for emergency purposes it is the responsibility of the owner or user to submit it for a periodic inspection within the specified interval.

The lists of gases in Tables 1 to 4 are intended as guides only. Reference shall be made to the manufacturer or inspection body if there is a question on the re-test period for specific gases.

Table 1 — Intervals for aluminium alloy liners ^(a)

Description	Gas ^(c)	Period (Years)
Compressed gases	e.g. Air, Ar, He, H ₂ , Ne, N ₂ , O ₂ , CH ₄ , CO and compressed gas mixtures	5 or 10 (see ^b and ^d)
Liquefied gases	e.g. CO ₂ , N ₂ O and liquefied gas mixtures	
Very toxic gases LC ₅₀ ≤ 200 p.p.m. V/V	e.g. AsH ₃ , PH ₃	3
^a Certain requirements may necessitate a shorter time interval e.g. presence of mercury in hydrogen, polymerisation and decomposition reactions. The compatibility of the gas to be filled with aluminium alloys shall be checked in accordance with ISO 11114-1. ^b For cylinders used for underwater operations and self-contained breathing apparatus, the re-test period shall not exceed five years. ^c This list of gases is not exhaustive. Gases shall be categorized in accordance with prEN 13096. ^d The longer test period may apply for cylinders of known designs and safe experience provided approval has been obtained from the competent authority and the manufacturer.		

Table 2 — Intervals for steel liners ^(a)

Description	Gas ^(g)	Period (Years)
Compressed gases	e.g. Ar, Xe, Ne, N ₂ , CH ₄ , and compressed gas mixtures	5 or 10 (see ^f)
	H ₂	5 or 10 (see ^e and ^f)
	Air, O ₂	5 or 10 (see ^b and ^f)
	CO	2,5 or 5 (see ^d)
Underwater breathing apparatus	Air, O ₂	2,5 (visual) and 5 (full)
Liquefied gases	e. g. CO ₂ , N ₂ O and liquefied gas mixtures	5 or 10 (see ^c and ^f)
Corrosive gases (to cylinder material)	e. g. Cl ₂ , F ₂ , NO, SO ₂ , HF	3
Very toxic gases LC ₅₀ ≤ 200 p.p.m. V/V	e. g. AsH ₃ , PH ₃	3
Gas mixtures	a) All mixtures except b) below b) Mixtures containing very toxic gases	a) Shortest period of any component b) If the toxicity of the final mixture is such that LC ₅₀ > 200 p.p.m. V/V, a 5 or 10 year period shall apply (see Note 6). If the toxicity of the final mixture is such that LC ₅₀ ≤ 200 p.p.m. V/V, a three year period shall apply.

^a Certain requirements may necessitate a shorter time interval e.g. the dew point of the gas, polymerisation reactions and decomposition reactions, cylinder design specifications, change of gas service etc. The compatibility of steel with the gas to be filled shall be checked in accordance with ISO 11114-1.

^b For cylinders used for self-contained breathing apparatus, the re-test period shall not exceed five years.

^c The longer 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. This condition shall be proven and documented within the quality system of the filler. If the conditions above cannot be fulfilled the cylinder shall be visually and internally inspected every five years and fully re-tested every 10 years.

^d The longer 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. This condition shall be proven and documented within the quality system of the filler. If the conditions above cannot be fulfilled the cylinder shall be visually and internally inspected every 2,5 years and fully re-tested every five years.

^e Particular attention shall be paid to the tensile strength and surface condition of such cylinders. Cylinders not conforming to the special hydrogen requirements specified in ISO 11114-1 shall be withdrawn from hydrogen service. Procedures for change of gas service shall be in accordance with EN 1795 or ISO 11621.

^f The longer test period can apply for cylinders of known designs and safe experience provided approval has been obtained from the competent authority and the manufacturer.

^g This list of gases is not exhaustive. Gases shall be categorized in accordance with prEN 13096.

Table 3 — Intervals for non-metallic liners ^(a)

Description	Gas (d)	Period (Years)
Compressed gases	e. g. Air, Ar, He, H ₂ , Ne, N ₂ , O ₂ , CH ₄ , CO and compressed gas mixtures	5 or 10 (See b and e)
Liquefied gases	e. g. CO ₂ , N ₂ O and liquefied gas mixtures	
Very toxic gases LC ₅₀ ≤ 200 p.p.m. V/V	e. g. AsH ₃ , PH ₃	3 (See c and e)
^a Certain requirements may necessitate a shorter time interval e. g. presence of mercury in hydrogen, polymerisation and decomposition reactions. The compatibility of the gas to be filled with non-metallic liners shall be checked in accordance with ISO 11114-2. ^b For cylinders used for underwater operations and self-contained breathing apparatus, the re-test period shall not exceed five years. ^c For mixtures involving these gases, if the toxicity of the final product LC ₅₀ > 200 p.p.m V/V, a 5 or 10 year period shall apply (see ^e). ^d This list of gases is not exhaustive. Gases shall be categorized in accordance with prEN 13096. ^e The longer test period may apply for cylinders of known designs and safe experience provided approval has been obtained from the competent authority and the manufacturer.		

Table 4 — Cylinders without liners ^(a)

Description ^(e)	Gas ^(c)	Period (Years)
Compressed gases	e. g. Air, Ar, He, H ₂ , Ne, N ₂ , O ₂ , CH ₄ , CO and compressed gas mixtures	5 or 10 (See ^b and ^d)
Liquefied gases	e. g. CO ₂ , N ₂ O and liquefied gas mixtures	
^a Certain requirements may necessitate a shorter time interval e. g. presence of mercury in hydrogen, polymerisation and decomposition reactions. The compatibility of the gas to be filled with non-metallic materials shall be checked in accordance with ISO 11114-2. ^b For cylinders used for underwater operations and self-contained breathing apparatus, the re-test period shall not exceed five years. ^c This list of gases is not exhaustive. Gases shall be categorized in accordance with prEN 13096. ^d The longer test period may apply for cylinders of known designs and safe experience provided approval has been obtained from the competent authority and the manufacturer. ^e Very toxic gases shall not be filled into this type of cylinder.		

5 Procedures for periodic inspection and test

5.1 List of procedures

The inspection, testing and repair of composite cylinders shall be carried out only by persons competent in the subject to ensure that the cylinders are fit for continued safe use.

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

- Identification of cylinder and preparation for inspection and test – (see clause 6);
- External visual Inspection – (see clause 7);
- Internal visual inspection – (see clause 8);
- Supplementary tests – (see clause 9);
- Pressure test – (see clause 10);

- Inspection of valve – (see clause 11);
- Final operations – (see clause 12);
- Rejection and rendering cylinders unserviceable – (see clause 13).

The internal visual examination (see clause 8) shall be carried out before the pressure test (see clause 10). It is recommended that the other tests are performed in the sequence listed above.

Cylinders which fail the inspection or testing shall be rejected (see clause 13). Where a cylinder passes the above listed procedures but when the condition of the cylinder remains in doubt, additional testing shall be performed to confirm its suitability for continued service or the cylinder shall be rendered unserviceable. Depending on the reason for the rejection cylinders may be recovered and/or repaired (see 7.4).

5.2 Heat exposure

When cylinders are refurbished during periodic inspection it may be necessary to expose them to heat, for example during initial cleaning, or as part of a stoving operation when painting or powder coating the cylinder. This heat exposure may affect the mechanical properties of the liners and/or the finished composite cylinder.

Therefore the maximum temperature to which these cylinders are exposed shall be controlled and shall not exceed 70° C for a period of 24 h, unless otherwise recommended by the cylinder manufacturer. In such cases the alternative limits shall be clearly indicated on the cylinder or otherwise.

6 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 or ISO 13769) and the gas contents (e.g. see EN 1089-2 or ISO 7225) shall be identified. The cylinder shall be depressurised and emptied in a safe controlled manner before proceeding. A method of dealing with cylinders with inoperative or blocked valves is outlined in annex A. The valve may then be removed.

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

7 External visual inspection

7.1 Preparation

The composite material and other integral parts of the composite cylinder shall not be removed prior to inspection. Where a transparent protective sleeve is used it may be left in place as long as the composite wrapping can be inspected effectively without removal. Where a non-transparent protective sleeve is used it shall be removed and only refitted after the pressure test.

Each cylinder shall be cleaned and have all loose paint, coatings, tar, oil or other foreign matter removed from its external surface by a suitable method (e.g. washing, brushing, controlled water jet cleaning, plastic bead blasting). Grit and shot blasting are not suitable. Chemical cleaning agents, paint strippers and solvents which are harmful to the composite cylinder or its materials shall not be used.

Composite cylinders also differ from their metal counterparts in that they may be repaired by a competent person where only limited damage has taken place (see 7.4). These limits are defined in Table 5 and following repair cylinders shall always be subjected to a pressure test before being returned to service.

7.2 Inspection procedures

The acceptance/rejection criteria given in Table 5 shall be followed, as a minimum. The inspection body shall contact the cylinder manufacturer to establish whether there are more stringent rejection criteria for the particular cylinder design. In case of doubt the inspection body shall make reference to the design drawing of the prototype. In the case where composite cylinders have been designed and manufactured for a limited lifetime, this is indicated on the cylinder marking. Therefore, the marking shall first be checked to ensure that such cylinders are within their lifetime. In the case of hoop wrapped cylinders the exposed external metal surfaces, especially the interface with the overwrapping, shall be inspected in accordance with the respective

parent periodic inspection and testing standard: i.e. prEN 1968 or ISO 6406 and prEN 1802 or ISO 10461 for steel and aluminium respectively.

The external surface shall be inspected for damage to the composite. There are three levels of damage that shall be considered of which only two may be repaired (see Table 5).

7.3 Types of damage

7.3.1 General

Damage to the composite overwrap can take a number of forms and examples of these are described in 7.3.2 to 7.3.5. The acceptance/rejection criteria are specified in Table 5, which refers to defined damage levels and the types of damage described in 7.3.2 to 7.3.5. Great care shall be taken to establish the total extent of damage from impact (see 7.3.4) and delamination (see 7.3.5) as surface appearance may not indicate the full extent of the damage. General damage to the cylinder is described in 7.3.6 to 7.3.11.

Annex B specifies additional damage criteria for steel wire wound aluminium alloy cylinders.

7.3.2 Abrasion damage (see Figures 1a) to 1c))

Abrasion damage is caused by wearing, grinding or rubbing away by friction. Minor abrasion damage to the protective coating or paint is shown in Figures 1a) and 1b). "Flat spots" evident on the surface could indicate excessive loss of composite overwrap thickness (see Figure 1c)).

7.3.3 Damage from cuts (see Figures 2a) to 2b))

Cuts or gouges are caused by contact with sharp objects in such a way as to cut into the composite overwrap, reducing its thickness at that point.

7.3.4 Impact damage (see Figures 3a) to 3b))

Impact damage may appear as hairline cracks in the resin, or delamination or cuts of the composite overwrap.

7.3.5 Delamination (see Figure 4)

Delamination is a separation of layers of strands, or of the strands themselves, of the composite overwrap. It may also appear as a whitish patch, like a blister or an air space beneath the surface.

7.3.6 Heat or fire damage (see Figures 5a) and 5b))

Heat or fire damage may be evident by discolouration, charring or burning of the composite overwrap, labels, paint or non-metallic components of the valve.

Where the composite overwrap is only soiled from smoke or other debris and is found to be intact underneath (e. g. no burning of the resin), the cylinder may be returned to service. Cylinders with damage greater than this shall be rendered unserviceable.

7.3.7 Structural damage

A cylinder shall be rendered unserviceable if there is any evidence of abnormal bulges, distorted valve connections, depressions not originally designed, or if, by visual examination of the cylinder interior, there is evidence of damage involving deformation of the liner.

7.3.8 Chemical attack (see Figure 6)

Chemical attack would appear as the dissolution of the resin matrix surrounding the fibres, the cylinder surface feeling "sticky" when touched. The cylinder shall be rendered unserviceable and the manufacturer be contacted for guidance.

7.3.9 Identification label

In case of illegibility of the label the manufacturer of the cylinder may be contacted.

In the event that the manufacturer can accurately identify the cylinder a supplementary identification label shall be affixed to the cylinder by the manufacturer. Otherwise the cylinder shall be rendered unserviceable.

7.3.10 Plug or neck inserts

Additional inserts in the composite cylinder neck are only permissible where it can be clearly established that they are part of the design of the prototype. The manufacturer shall be referred to for guidance and in the event that they do not conform to the design of the prototype, the cylinder shall be rendered unserviceable.

7.3.11 Permanent attachments

Where a collar or neck ring or other permanent attachment has been affixed to the composite cylinder it shall be checked with reference to the design drawing of the prototype. The manufacturer shall be referred to for guidance and in the event that it does not conform to the design drawing, the cylinder shall be rendered unserviceable.

Where there are any signs of the attachments becoming loose, they may be repaired and the manufacturer shall be referred to for guidance.

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Table 5 — Acceptance/rejection criteria

Type of damage	Level of damage		
	Level 1 Acceptable damage	Level 2 Rejectable damage - requiring additional inspections or repairs	Level 3 Condemned damage - not repairable
Abrasion damage or damage from cuts	Damage from abrasion or cuts to the following depths are acceptable: - 5% of composite overwrap thickness for fully wrapped cylinders; - 10% of composite overwrap thickness for hoop wrapped cylinders.	Damage may be cuts or gouges which are deeper or longer than those of level 1, or may include a group of damaged strands or rovings. This level of damage may be repairable. (See ^a). Only damage from abrasion and cuts is permitted to be repaired for defects up to and including: - 15% of composite overwrap thickness for fully wrapped cylinders; - 30% of composite overwrap thickness for hoop wrapped cylinders; provided that in either case the maximum length of the above defect is less than 50% of the external diameter of the cylinder.	Damage is such that the cylinder is no longer suitable for continued service and shall be rendered unserviceable.
Impact damage	Damage from impact which is relatively slight and causes a frosted appearance or hairline cracking in the impact area is acceptable.		
Delamination	Only minor delamination of the exterior coating is acceptable.	Loose fibre ends from the termination of the wrapping process shall be repaired. (See ^a).	
Other damage	- Minor damage that would be considered normal. Such damage should have no adverse effects on the safety of the cylinder and its continued use. - Damage that has no appreciable depth or small groups of abraded fibres are considered in this category.		
^a The damaged area shall be repaired with a resin compatible with the existing matrix (see 7.4)			

7.4 Repairs

A resin system may be used to repair composite cylinders. Reference shall be made to the design drawing of the prototype, or the manufacturer for confirmation of the resin system and repair procedure to be used.

All repaired cylinders shall be subjected to a pressure test before being returned to service. After pressure test the repairs shall be examined for lifting, peeling or delamination of the composite overwrap. The damage criteria identified in 7.3 shall be used.

A sequence of photographs illustrating a typical repair procedure is shown in Figures 7a) to 7e).

In the event of a failure, if it can be established that the repair procedure was inadequate or not followed then a second and final repair may be performed. Any cylinder showing signs of delamination after a second pressure test shall be rendered unserviceable.

8 Internal visual inspection

8.1 General

The whole of the internal surface of each cylinder shall be inspected, using an adequate technique and illumination to identify any defects present. Any cylinder showing presence of foreign matter or signs of more than light surface corrosion shall be cleaned internally under closely controlled conditions by controlled water jet cleaning, flailing, steam jet (see 5.2), rumbling with ceramic chips or other suitable method (grit or shot blasting is considered most suitable for steel liners). Any chemical solutions and/or cleaning methods used shall be selected to ensure that they do not adversely affect the liner or composite overwrap materials. Care shall be taken to avoid damaging the cylinder. After cleaning and drying, the cylinders shall be inspected again and any cylinder showing excessive corrosion, dents or cracks shall be rendered unserviceable.

For steel or aluminium alloy liners, the inspection shall be in accordance with prEN 1968 or ISO 6406, or prEN 1802 or ISO 10461 respectively.

For cylinders without liners or with non-metallic liners the following criteria shall be used:

Any cylinder showing presence of foreign matter or signs of more than light surface corrosion shall be cleaned internally under closely controlled conditions by controlled water jet cleaning or a method recommended by the manufacturer. Any chemical solutions used for cleaning and/or cleaning methods used shall be strictly in accordance with the cylinder manufacturer's procedures.

After cleaning and drying, the cylinders shall be inspected again and any cylinder showing discolouration or other surface defects such as heat damage shall be permeability tested (see clause 9).

8.2 Inspection of cylinder neck/shoulder

8.2.1 Neck threads

The neck threads (valve connections) of the cylinder shall be inspected and gauged to ensure that they are:

- clean and of full form;
- free from burrs or damage;
- free from cracks.

Additional information on neck and shoulder cracks can be found in prEN 1802 or ISO 10461 and prEN 1968 or ISO 6406.

8.2.2 Damaged neck threads

Where necessary and where the manufacturer 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 using the appropriate thread gauge (e.g. EN 629-2 for 25E threads).

9 Permeability testing

Where there is doubt concerning the type or severity of a defect found on visual inspection additional tests or methods of examination may be applied. The following method for permeability testing is recommended but alternatives are permitted which achieve the same result.

This entire test shall be performed at a temperature of $(20 \pm 5) ^\circ\text{C}$. The cylinder shall be charged to its working pressure with air or an inert gas and the valve and the junctions of the liner (if present) with the metallic bosses or rings shall be visually checked for leaks (e.g. with soapy water). Any leaks shall be eliminated, where the design permits, before proceeding with this test.

The cylinder is then recharged, if necessary, to its working pressure, weighed and the mass of the stored gas recorded. The accuracy of the weighing scales shall be such as to detect the expected mass change. The cylinder shall be weighed after 24 h (or longer in case of any doubt) and the loss of mass shall be determined.

The rate of loss shall be less than $0,25 \text{ ml.hr}^{-1}$ per litre of cylinder water capacity. If the leakage rate is greater or equal to $0,25 \text{ ml.hr}^{-1}$ per litre of cylinder water capacity then the cylinder shall be rejected.

NOTE Adequate safety precautions should be taken to contain any energy which may be released.

10 Pressure test

Each cylinder shall be submitted to a pressure test using a suitable fluid, normally water, as the test medium. This may be a proof pressure test, or a volumetric expansion test (see annex C), as appropriate to the design of the cylinder. The method used shall not reduce the integrity of the cylinder. The pressure test method used need not be the same as that used at the time of manufacture unless specified in the design. 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. All types of composite cylinder covered by this standard shall be tested according to prEN 1968 or ISO 6406 or prEN 1802 or ISO 10461 as appropriate. The test pressure shall be established from the marking on the cylinder.

The proof pressure test requires that the pressure in the cylinder is increased gradually until the test pressure is reached. The cylinder test pressure shall be held for at least 30 s to ascertain that there is no tendency for the pressure to decrease and that tightness is guaranteed. Adequate safety precautions shall be taken during the test. Any cylinder failing to conform to with the requirements of this test shall be rendered unserviceable.

Only a proof pressure test shall be used for testing composite cylinders wound with steel wire.

NOTE In the case where a pneumatic pressure test is carried out appropriate measures should be taken to ensure safe operation and to contain any energy which may be released.

If a water jacket is used for a volumetric expansion test air may be expelled from the composite overwrap or water absorbed by the composite overwrap during the pressurisation cycle. The design of the test equipment and/or test procedure may need to be modified to take these factors into account.

The permanent volumetric expansion shall not exceed 5 % or such lower figure as required by the competent authority for a specific design.

11 Inspection of valve

If a valve is to be reintroduced into service, it shall be inspected to ensure that it will perform satisfactorily and ensure gas tightness. An example of how this may be achieved is given in annex D.

12 Final operations

12.1 Drying and cleaning

The interior of each cylinder shall be thoroughly dried by a suitable method immediately after the pressure test, 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. Should heat be used care shall be taken to ensure that the maximum temperature and time indicated in 5.2 are not exceeded.

12.2 Painting

Cylinders are sometimes repainted using paints which require stoving. In these circumstances care shall be taken to ensure that the maximum time and temperature as indicated in 5.2 are not exceeded, so that the cylinder is not degraded in any way. It is recommended that the manufacturer is referred to for appropriate painting procedures for their cylinders. Care shall be taken that the identification label is masked out prior to painting to ensure its continuing legibility.

12.3 Cylinder re-valving

Before re-valving the cylinder the neck thread shall be inspected in accordance with 8.2.

The valve shall be fitted to the cylinder using a suitable method of sealing. The optimum torque necessary to ensure both the seal between the valve and the cylinder and prevent any possibility of over stressing of the neck shall be used, in accordance with 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 method used, according to the cylinder manufacturer's recommendations. Where the use of lubricants/sealing material is permitted only those compatible with the gas service shall be used, taking particular care for oxygen service, in accordance with ISO 11114-2 and ISO 13341.

12.4 Check on cylinder tare

The requirements shall only apply to cylinders for liquefied gases and compressed gases filled by weight. The tare of the cylinders shall be obtained by weighing on a machine regularly calibrated and checked for accuracy. The capacity of the weighing machine shall be suitable for the tare weight of the appropriate 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 marked tare by more than the value shown in Table 6 and is not due to reason of damage, the original tare shall be cancelled and the correct tare marked in a permanent and legible fashion, in accordance with EN 1089-1 or ISO 13769.

Table 6 — Allowable deviation in cylinder tare weight

Cylinder water capacity l	Maximum allowable deviation in tare weight g
≤ 5	± 50
> 5 to < 20	± 200
≥ 20	± 400

12.5 Marking

After satisfactory completion of the periodic inspection and test each cylinder shall be permanently marked or labelled according to EN 1089-1 or ISO 13769, with:

- a) the present test date; followed by;
- b) symbol of the inspection body or test station.

12.6 Reference to next test date

The next test date shall be shown by an appropriate method such as a disc fitted between the valve and the cylinder, indicating the date (year) of the next periodic inspection test.

12.7 Identification of contents

Where required by cylinder owner/operator the cylinder contents shall be identified in accordance with EN 1089-2 or ISO 7225 and EN 1089-3 or ISO 32. If painting is required care shall be exercised in accordance with 12.2 of this standard. If a change of gas service is involved, the requirements of EN 1795 or ISO 11621 shall be conformed to.

NOTE Users of this standard should take account of legal requirements on identification which may be applicable in the country of use.

12.8 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 mass or tare where applicable;
- Test pressure;
- Present test date;
- Identification symbol of inspection body or 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;
- Manufacturing specification;
- Water capacity/size.

All information regarding the test shall be retained by the test station and shall be made available to the manufacturer for the life of the cylinder.

13 Rejection and rendering cylinders unserviceable

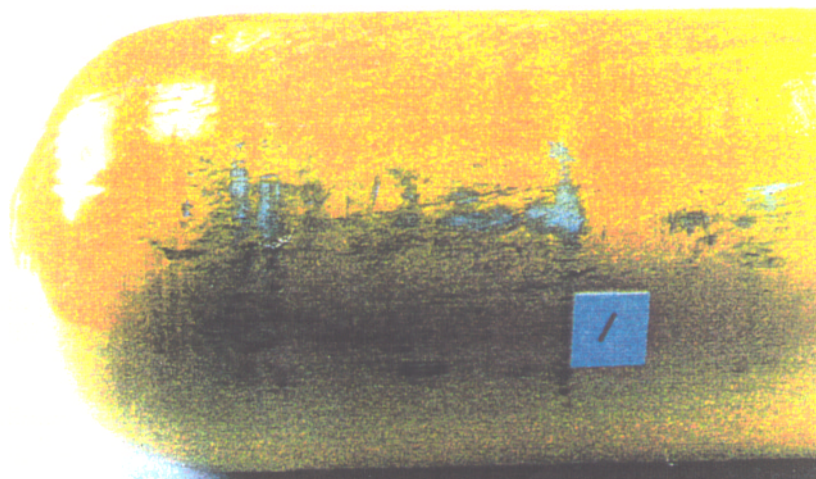
The decision to reject a cylinder may be taken at any stage during the inspection and test procedure. If it is not possible to recover a rejected cylinder it shall, after notifying the owner, be made unserviceable by the test station for holding gas under pressure so that it cannot be reissued into service.

NOTE In case of any disagreement, ensure that the legal implications of the contemplated action are fully understood.

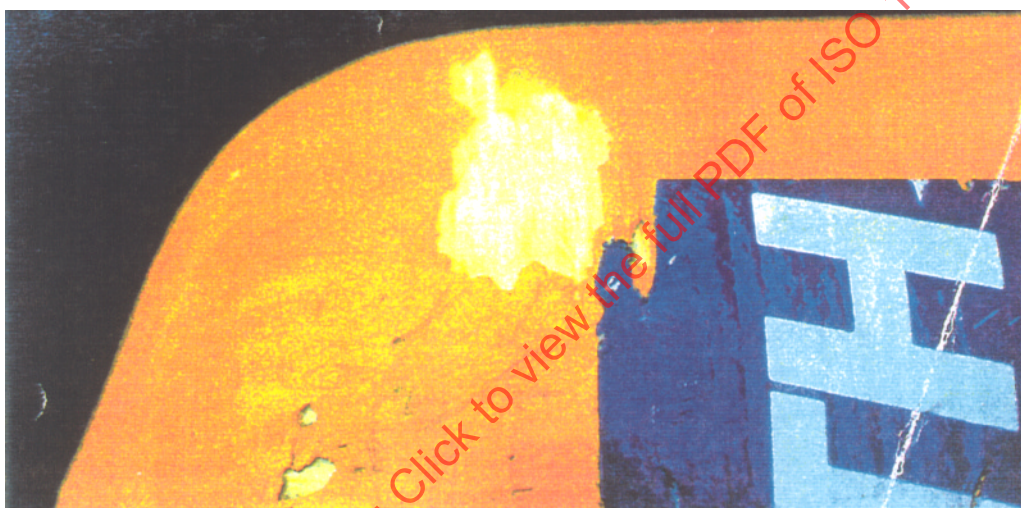
One of the following methods shall be employed:

- By crushing the cylinder using mechanical means;
- Cutting the neck off the cylinder;
- Irregular cutting of the cylinder in two or more pieces;
- By hydraulically pressurising the cylinder to failure, although care shall be taken to ensure that this is carried out in a safe manner.

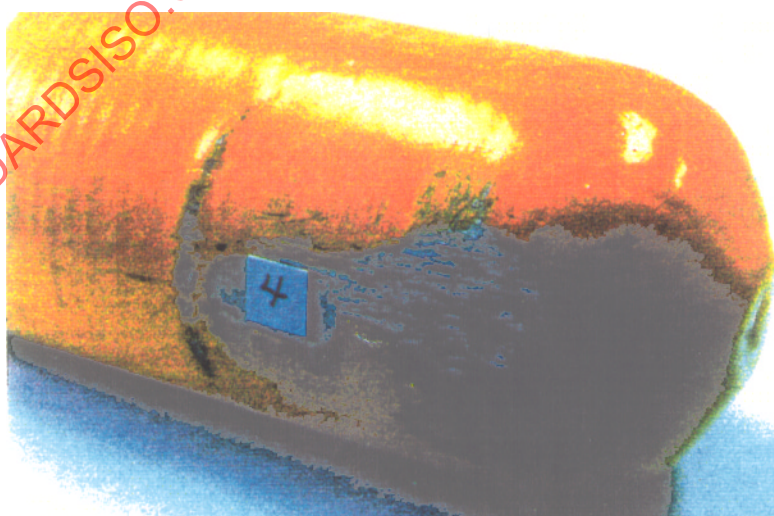
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a) Level 1 abrasion damage — Superficial abrasion

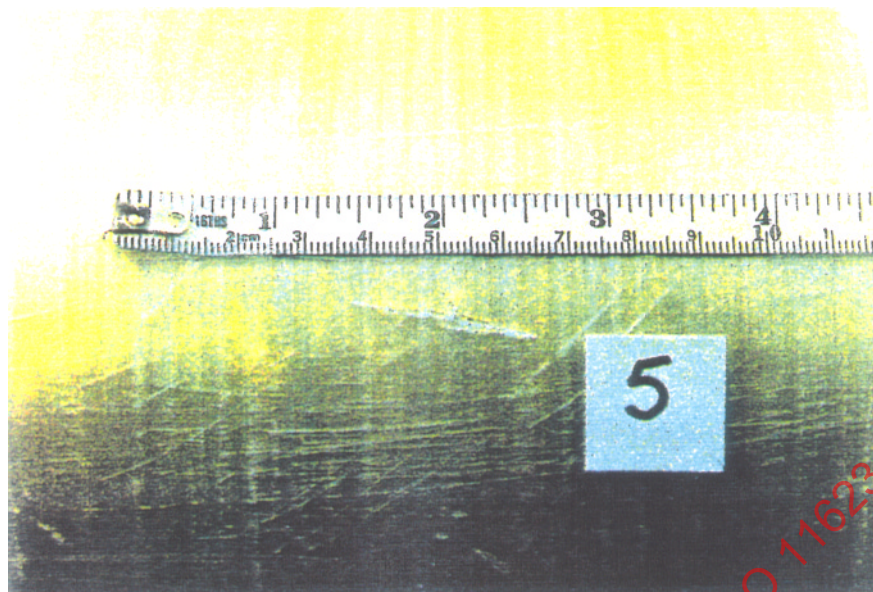


b) Level 2 abrasion damage — Depth of abrasion between 5 % and 15 % of thickness (fully wrapped cylinder)

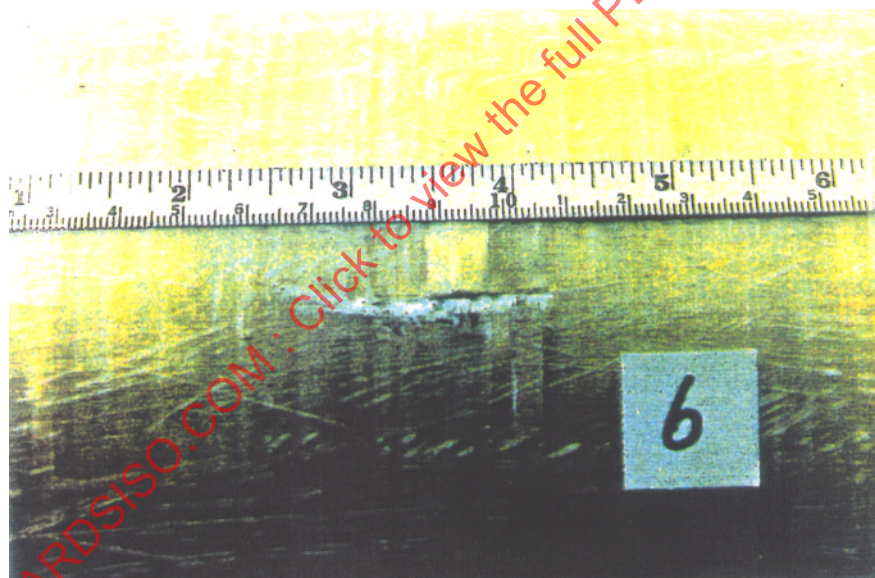


c) Level 3 abrasion damage — Severe abrasion over 15 % of thickness

Figure 1 — Abrasion damage

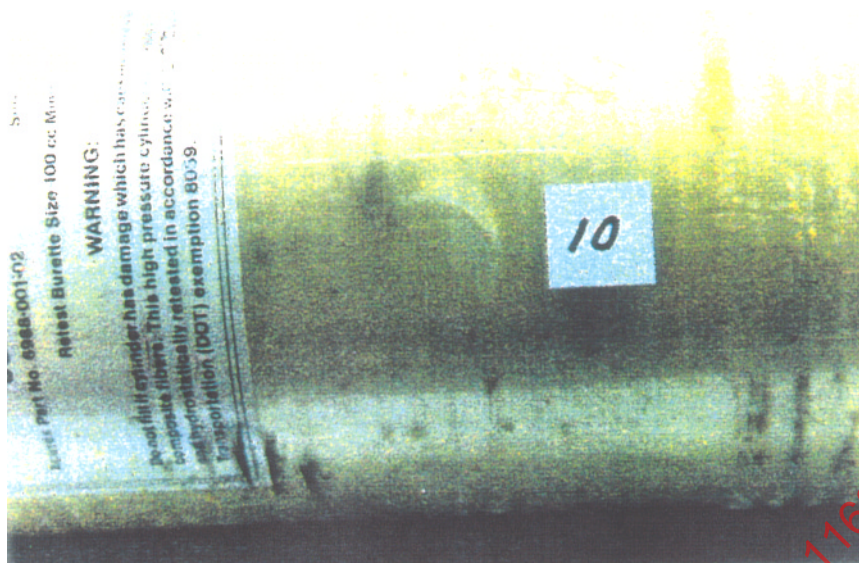


a) Level damage from cuts — Superficial cut

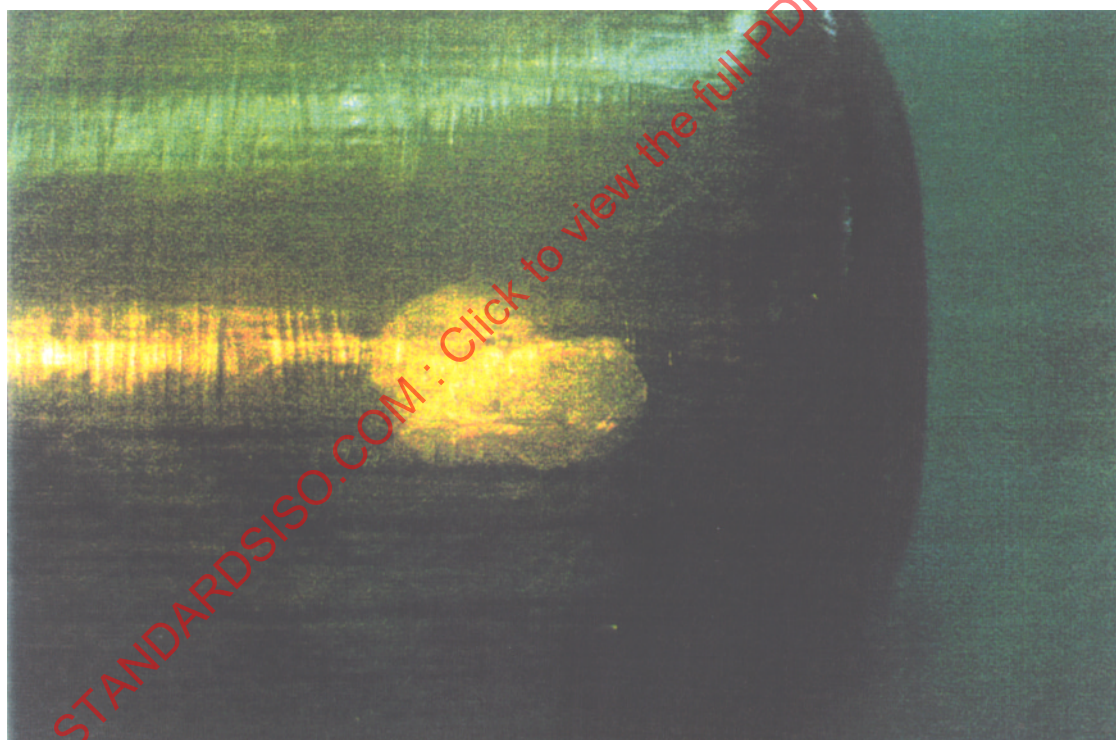


b) Level 2 damage from cuts — Depth of cut between 10 % and 30 % of thickness (hoop wrapped cylinder)

Figure 2 — Damage from cuts



a) Level 1 impact damage — Superficial impact damage

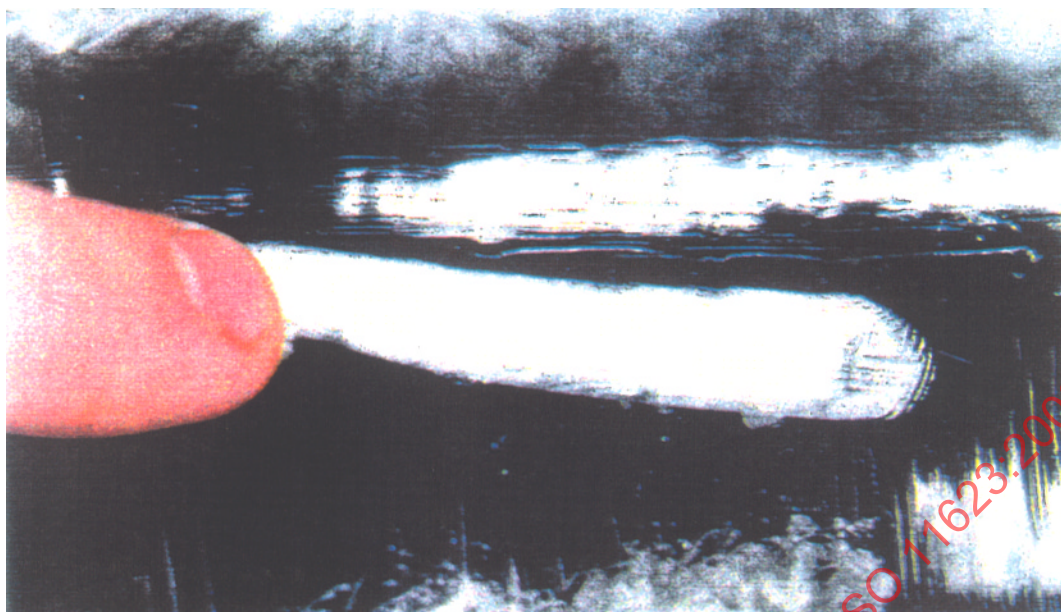


b) Level 3 impact damage — Depth of damage over 15 % of thickness
(fully wrapped cylinder)

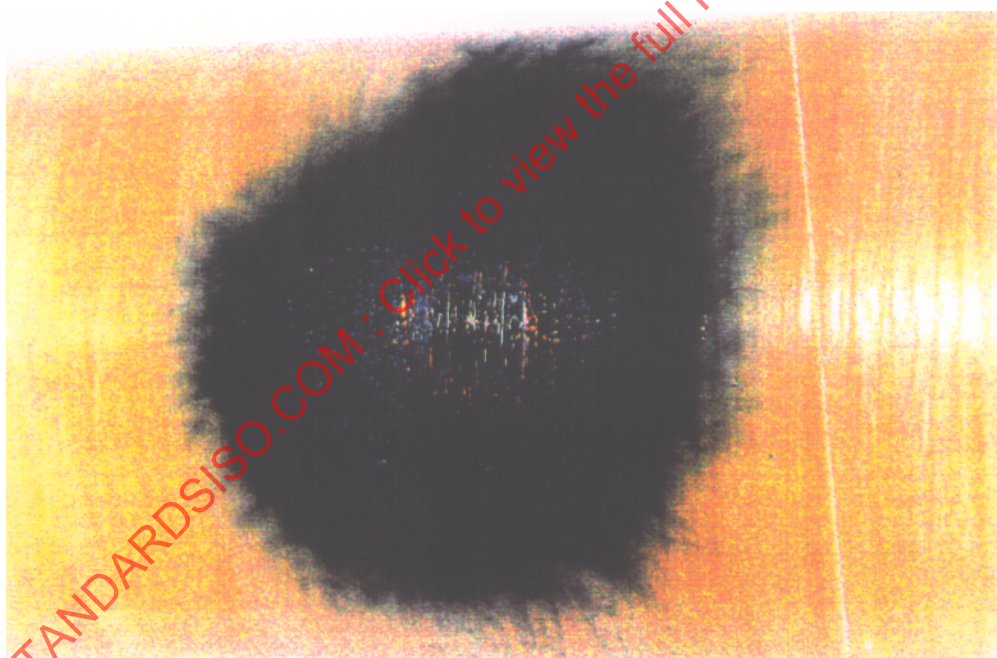
Figure 3 — Impact damage



Figure 4 — Delamination



a) Level 1 fire damage — Surface charring only



b) Level 3 fire damage

Figure 5 — Heat or fire damage

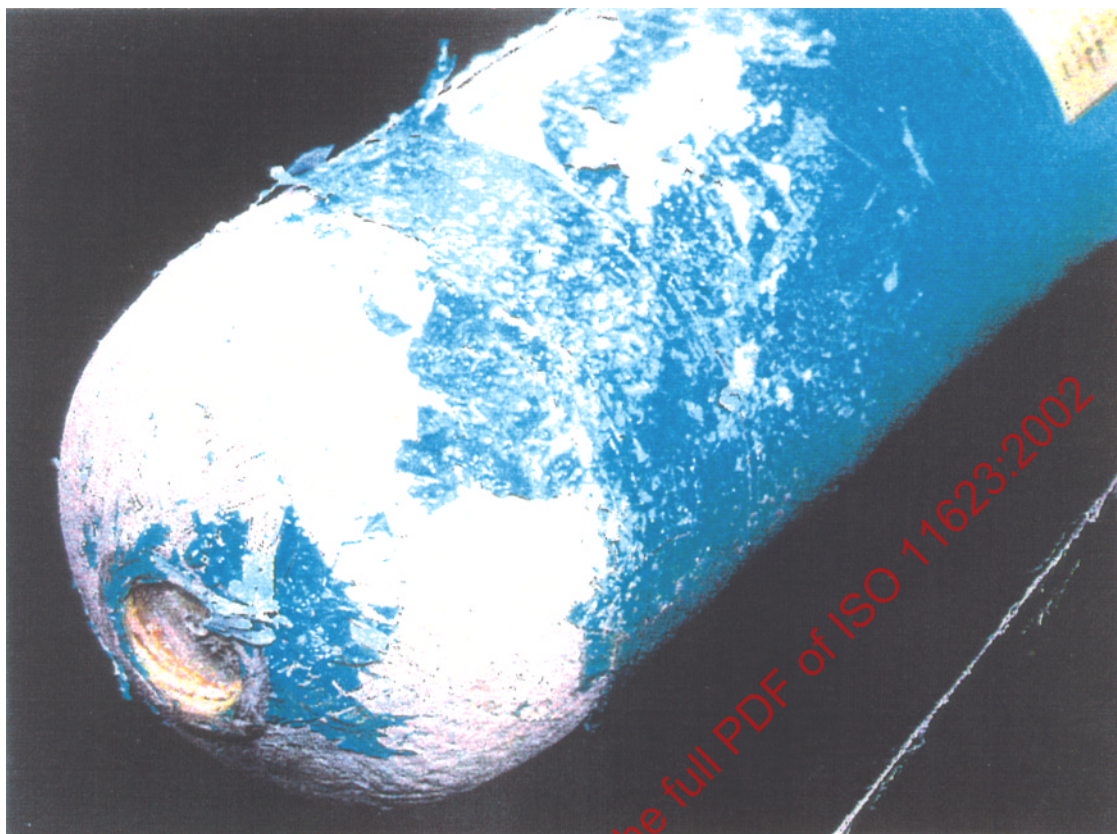
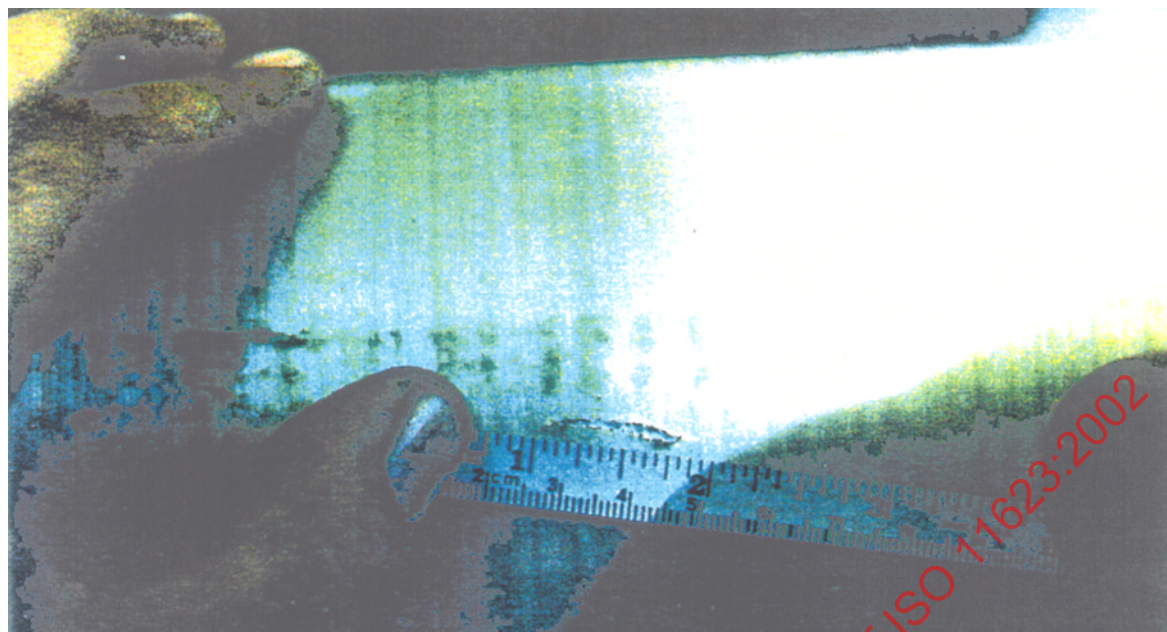
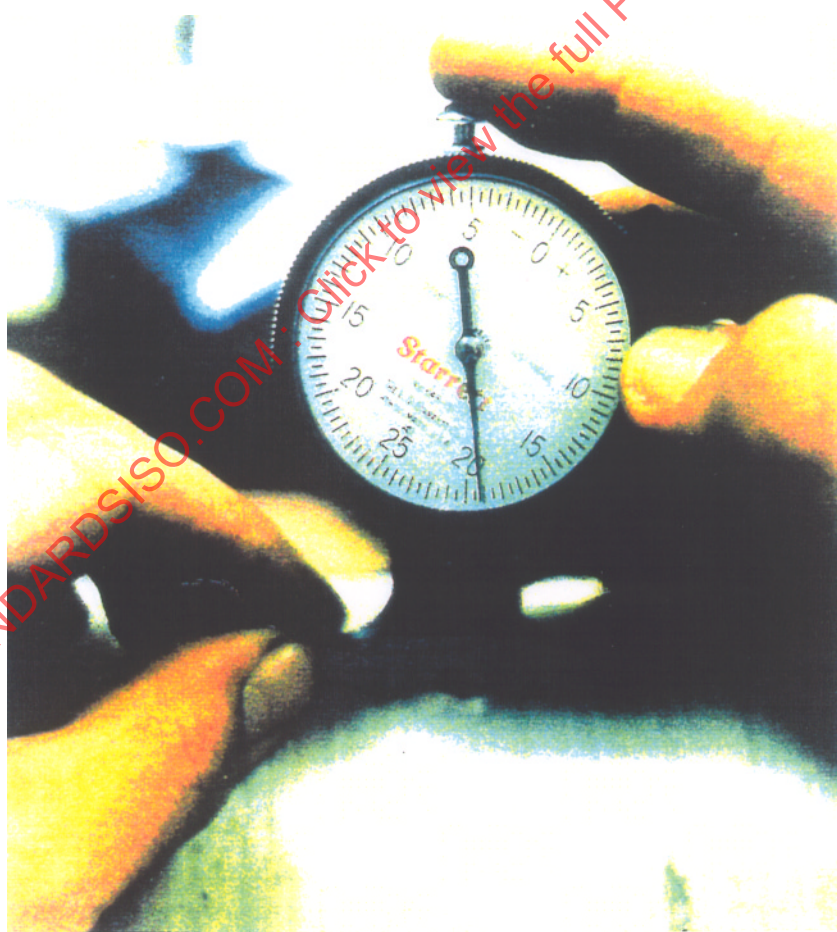


Figure 6 — Chemical attack (24 h in paint stripper)



a) Length measurement



b) Depth measurement



c) Resin mixing



d) Resin application



e) After cure

Figure 7 — Typical repair procedure

Annex A (informative)

Example of procedure to be adopted when a cylinder valve is suspected of being obstructed

The methods suggested herein for dealing with cylinder valves which are suspected of being obstructed have been found to produce satisfactory results. Other acceptable methods may be employed.

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

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

- a) By introducing gas at a pressure up to 5 bar and checking its discharge.
- b) By using the device shown in Figure A.1 to hand pump inert gas into the cylinder.
- c) For cylinders of liquefied gases, first check to establish that the total weight of the cylinder is the same as the tare stamped on the cylinder. If there is a positive difference, the cylinder may contain either liquefied gas under pressure or contaminants.

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

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:

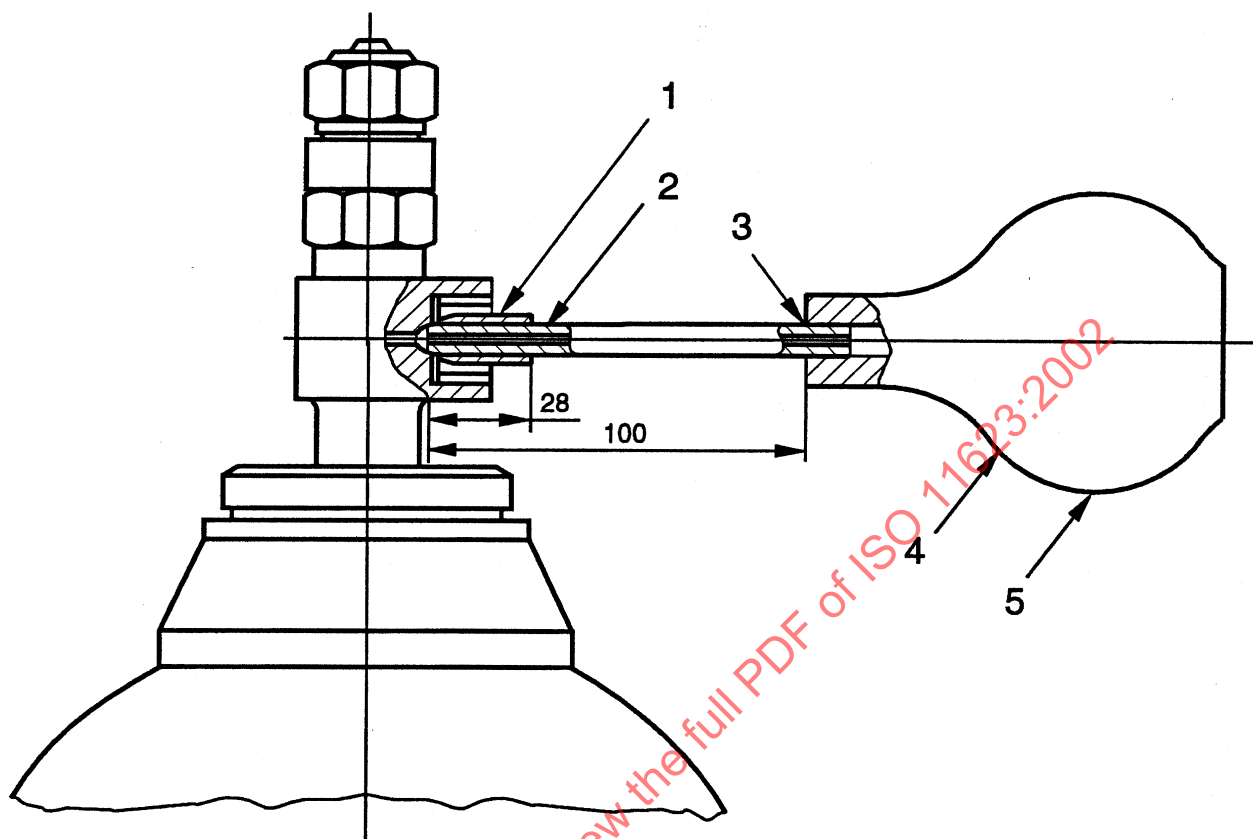
- a) By sawing or drilling the valve body until interception is made with the gas passage between the valve body stem and valve spindle seat. This operation shall be properly cooled particularly when handling oxidising gases.
- b) By loosening or piercing the safety device in a controlled manner.

These methods are applicable for cylinders of non-toxic, non-flammable 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 or flammable, 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 A.2.

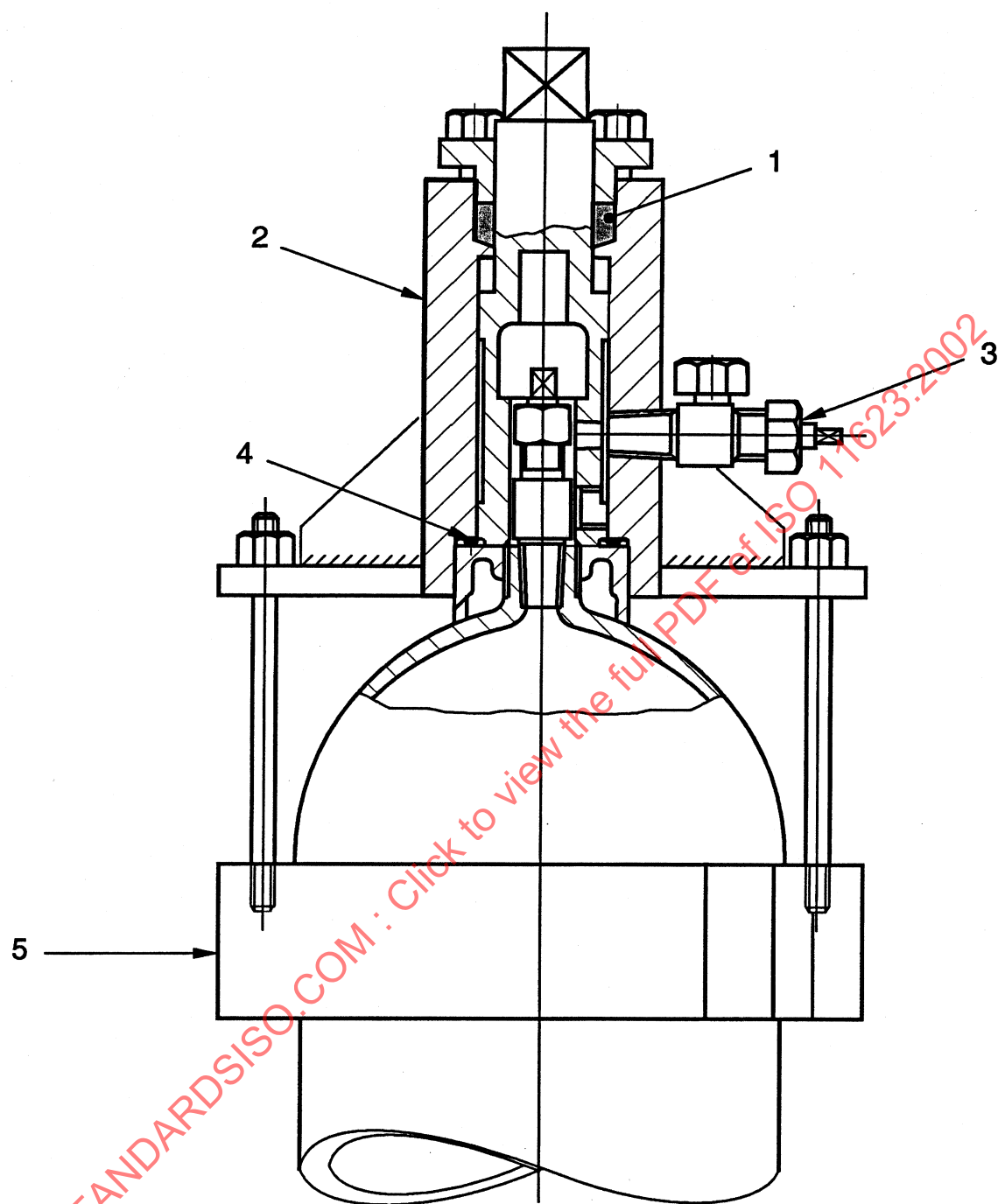
These procedures may be carried out only by trained personnel. When the gas, if any, has been released and the pressure within the cylinder reduced to atmospheric, and, in the case of liquefied gases, there is no frost or dew on the outside of the cylinder, the valve may be removed.

Dimensions in millimetres

**Key**

- 1 Rubber tube 8 inner diameter $\times$ 13 outer diameter ground to olive shape and bonded
- 2 Copper tube 3 inner diameter $\times$ 8 outer diameter
- 3 Bond
- 4 Rubber bulb
- 5 Hand pressure

Figure A.1 — Device for detecting obstructed cylinder valve



Key

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

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

Annex B

(normative)

Damage criteria for wire wound aluminium alloy cylinders

This annex covers specific damage criteria additional to those described in 7.3.

The steel wire shall not be removed for the purposes of this inspection.

The specific criteria are:

a) Corrosion damage:

Corrosion of the liner may appear as pitting, alumina powder or bulges under the steel wire. Corrosion of the steel wire is characterised by the presence of rust.

Slight corrosion of the steel wire may be repaired by adequate surface preparation followed by its protection (e.g. painting). Heavy corrosion of the steel wire will render the cylinder unserviceable. If any corrosion of the liner underneath the steel wire is observed, the cylinder will be rendered unserviceable.

b) Loosening of steel wire:

The steel wire may lose its tension. In such cases, whereas the individual hoops of the winding were originally in contact with one another, separation will have occurred.

All such types of failure will render the cylinder unserviceable.

c) Failure of aluminium retainers at the ends:

The steel wires are kept in position by aluminium retainers. Mishandling or corrosion may force the retainers to be dislodged. This type of failure can be detected visually. All such types of failure will render the cylinder unserviceable.

Annex C (informative)

Volumetric expansion testing of gas cylinders

C.1 General

This annex gives details of the two methods of determining the volumetric expansion of composite gas cylinders.

- a) The water jacket method
- b) The non-water jacket method

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

C.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 twice the maximum test pressure of any cylinder that may be tested.
- b) Glass burettes shall be of sufficient length to contain the full volumetric expansion of the cylinder and shall have bore of uniform diameter such that the expansion can be read to an accuracy of 1 % or 0,1 ml, whichever is the greater.
- c) Weighing scales shall be to an accuracy of 1 % or 0,1 g whichever is the greater.
- d) Pressure gauges shall be of the industrial class 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) Pipework 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 twice 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.

C.3 Water jacket volumetric expansion test

C.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 may burst at test pressure.

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

Two methods of performing this test are described in C.3.2 and C.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.

C.3.2 Water jacket volumetric expansion – Levelling burette method

The equipment should be installed as shown in Figure C.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.

C.3.3 Water jacket volumetric expansion test – Fixed burette method

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

Procedure:

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

Follow procedures C.3.2 a) and b);

Connect the cylinder to the pressure line;

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;

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;

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.