INTERNATIONAL STANDARD

ISO 11623

Second edition
2015-12-01

Gas cylinders — Composite construction — Periodic inspection and testing

Bouteilles à gaz — Construction composite — Contrôles et essais périodiques

Reference number
ISO 11623:2015(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*.

This second edition cancels and replaces the first edition (ISO 11623:2002), which has been technically revised with the following changes:

— up-to-date terminology particularly for the various types of composite cylinders;

— up-to-date normative references for steel and aluminium-alloy liner materials;

— list defects according to severity with an additional set of acceptance/rejection criteria;

— replacement of the procedure regarding obstructed cylinder valve (former Annex A) with a reference to ISO 25760;

— addition of a new, normative Annex B for the internal inspection of translucent composite cylinders;

— information regarding intervals between periodic inspection and testing based on cylinder type, formerly listed in Tables 1 through 4, moved into new, informative Annex C;

— update of some photographs to provide sharper examples of damage.

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Introduction

The principal aim of periodic inspection and testing is that at the completion of the test, the cylinders can be reintroduced into service for a further period of time. It is not possible to identify all considerations for periodic inspection and testing of composite cylinders in this International Standard. In such cases or where there is doubt, questions regarding specific cylinders should be directed to the manufacturer or owner.

This International Standard is intended to be used under a variety of national regulatory regimes, but has been written so that it is suitable for the application of the UN Model Regulations (see Reference [1]). Attention is drawn to requirements in the relevant national regulations of the country (countries) where the cylinders are intended to be used that might override the requirements given in this International Standard. Where there is any conflict between this International Standard and any applicable regulation, the regulation always takes precedence.

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Gas cylinders — Composite construction — Periodic inspection and testing

1 Scope

This International Standard specifies the requirements for periodic inspection and testing and to verify the integrity for further service of hoop-wrapped and fully-wrapped composite transportable gas cylinders, with aluminium-alloy, steel or non-metallic liners or of linerless construction (Types 2, 3, 4, and 5), intended for compressed, liquefied or dissolved gases under pressure, of water capacity from 0,5 l up to 450 l.

This International Standard is written to address the periodic inspection and testing of composite cylinders constructed to ISO 11119-1, ISO 11119-2, and ISO 11119-3 standards and can be applied to other composite cylinders designed to comparable standards when authorized by the competent authority.

As far as practicable, this International Standard also can be applied to cylinders of less than 0,5 l water capacity.

2 Normative references

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

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

ISO 6406, *Gas cylinders — Seamless steel gas cylinders — Periodic inspection and testing*

ISO 7225, *Gas cylinders — Precautionary labels*

ISO 10461, *Gas cylinders — Seamless aluminium-alloy gas cylinders — Periodic inspection and testing*

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

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

ISO 13341, *Gas cylinders — Fitting of valves to gas cylinders*

ISO 13769, *Gas cylinders — Stamp marking*

ISO 25760, *Gas cylinders — Operational procedures for the safe removal of valves from gas cylinders*

3 Terms and definitions

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

3.1
composite overwrap
fibres (3.3) and *matrix* (3.14) taken together as a combined unit

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3.2
exterior coating
layer of material applied to the cylinder as a protective coating not intended to be removed or for cosmetic purposes

EXAMPLE Gel coat and paint.

Note 1 to entry: Not all composite cylinders will have a special exterior coating.

3.3
fibre
load-carrying part of the *composite overwrap* (3.1)

EXAMPLE Glass, aramid or carbon.

3.4
fully-wrapped composite cylinder without liner
cylinder manufactured only from continuous *fibre* (3.3) strands in a *matrix* (3.14) wrapped in both circumferential and longitudinal directions

Note 1 to entry: Also known as Type 5.

3.5
fully-wrapped composite cylinder with liner
steel, aluminium-alloy or non-metallic *liner* (3.10) wrapped with continuous *fibre* (3.3) strands in a *matrix* (3.14) both circumferentially and longitudinally

Note 1 to entry: Also known as either Type 3 (metallic liner) or Type 4 (non-load sharing liner).

3.6
hoop-wrapped composite cylinder
seamless steel or aluminium-alloy *liner* (3.10) wrapped with continuous *fibre* (3.3) strands or steel wire [embedded in a *matrix* (3.14)] around only the cylindrical body of the liner, leaving the metal in the neck and base regions exposed

Note 1 to entry: Also known as Type 2.

3.7
translucent composite cylinder
cylinder that permits the passage of light

3.8
identification label
label containing the permanent markings required by the relevant design specification

3.9
design life
maximum life (in number of years) to which a composite cylinder or tube is designed and approved in accordance with the applicable standard

3.10
liner
inner portion of the composite cylinder designed both to contain the gas and transmit the gas pressure to the *composite overwrap* (3.1)

3.11
non-metallic liner
liner (3.10) made from thermoplastic, thermosetting, or elastomeric material

3.12
protective sleeve
transparent or non-transparent cover fitted to the outside surface of the cylinder

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3.13
repair
minor refurbishment to return the cylinder to its acceptable condition

EXAMPLE Adding resin.

3.14
matrix
material used to bind and hold the *fibres* (3.3) in place

Note 1 to entry: The matrix is sometimes called resin.

3.15
rejected cylinder
cylinder not fit for service or which needs to be set aside for further evaluation or testing in its present condition

3.16
Level 1 damage
DEPRECATED: Level 1 condition
minor damage that can occur during normal use

3.17
Level 2 damage
DEPRECATED: Level 2 condition
damage that is more severe than *Level 1* (3.16) and, where *repair* (3.13) is authorized and where the cylinder can be returned to service, or based upon the recommendations of the manufacturer to be classified as Level 1 or *Level 3* (3.18)

3.18
Level 3 damage
DEPRECATED: Level 3 condition
damage that requires a cylinder to be condemned, i.e. rendered unfit for continued service

3.19
bulge
visible swelling of the wall

3.20
crack
split or separation in the material, typically appearing as a line on the surface

3.21
crease
off-colour linear or non-linear feature formed as a result of previous localized over-stressing

3.22
protective attachment
component connected to the cylinder that prevents or resists damage to the composite cylinder

EXAMPLE Casing.

Note 1 to entry: Some protective attachments are designed to be removed at the time of periodic inspection and testing.

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4 Due dates for periodic inspection and testing

A cylinder shall be due for periodic inspection and testing on its first receipt by a filler after the expiry of the due date.

NOTE There is no general requirement for the user to return a gas cylinder before the contents have been used even though the test interval has lapsed.

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

In some jurisdictions, it is the responsibility of the owner or user to submit cylinders used for emergency purposes for periodic inspection and testing within the specified interval.

5 Procedures for periodic inspection and testing

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. Care shall be taken to ensure that during the retest procedure, cylinders are handled carefully, particularly with respect to loading in and out of metal pallets, and ensuring cylinders are not dropped to cause any damage.

Each cylinder shall be submitted to periodic inspection and testing. The following procedures form the requirements for this periodic inspection and testing and are explained more fully in this International Standard:

— Identification of cylinder and preparation for periodic inspection and testing (see Clause 6);

— External visual inspection (see Clause 7);

— Safe removal of valve (see 8.1);

— Internal inspection and cleaning (see 8.2);

— Pressure test (see Clause 9);

— Leak test (see Clause 10);

— Inspection of valve (see Clause 11);

— Final operations (see Clause 12); and

— Rejection and rendering cylinders unserviceable (see Clause 13).

The external and internal visual examination (see Clauses 7 and 8) shall be carried out prior to the pressure test (see Clause 9). It is recommended that the other tests are performed in the sequence listed above; however, when a valve is removed, ISO 25760 shall be observed.

Cylinders that fail inspection or testing shall be rejected (see Clause 13). When a cylinder passes the above-listed procedures but 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 might 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 can affect the mechanical properties of the liners and/or the finished composite cylinder.

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It is therefore essential that information on precise heat-effect temperatures from the cylinder manufacturer be available; in the absence of this information, cylinders shall not be exposed to a temperature exceeding 70 °C during refurbishment. If the cylinder's allowable temperature is greater than 70 °C, then that temperature and the maximum exposure time at that temperature shall be indicated on the cylinder by the manufacturer. Otherwise, the inspector shall obtain documentation indicating the cylinder's suitability for higher temperatures.

6 Identification of cylinder and preparation for periodic inspection and testing

Before any work is carried out, the relevant cylinder markings (e.g. see ISO 13769) and the gas contents (e.g. see ISO 7225) shall be identified. First, the marking shall be checked to ensure that the cylinder in question is within its design life. When composite cylinders have been designed and manufactured for a limited design life, this is indicated on the cylinder marking.

The cylinder shall be depressurized and emptied in a safe, controlled manner before proceeding. Prior to valve removal, the user shall follow procedures described in ISO 25760. In particular, a positive check shall be made to ensure that the cylinder is empty of gas. Provided the requirements as stated in ISO 25760 have been complied with, the cylinder shall be depressurized safely and the valve removed.

Cylinders with unknown gas contents shall be emptied as if the gas is dangerous (i.e. toxic, flammable or oxidizing). When the valve is non-functional, cylinders shall be emptied safely as described in ISO 25760.

7 External visual inspection

7.1 Preparation

7.1.1 The composite material including any exterior coating applied for protection shall never be removed for the visual inspection.

Permanent attachments of the composite cylinder shall not be removed prior to inspection, provided that these attachments are part of the original design and the manufacturer can produce documentation necessary to identify which defects have no adverse effect on the cylinder's integrity.

Markings specific to permanent attachments on the cylinder shall indicate if the attachments must remain in place at the time of the periodic inspection and testing. If such markings are not present, the cylinder manufacturer shall be consulted to establish whether the permanent attachments need to be removed.

7.1.2 When a transparent protective sleeve is used, it may be left in place as long as the composite wrapping can be inspected effectively without its removal.

When a non-transparent protective sleeve is used that is not part of the cylinder design, it shall be removed and only refitted after this inspection and the pressure test.

7.1.3 Each cylinder shall be cleaned and have all loose foreign matter removed from its external surface by a suitable method (e.g. washing, light brushing, controlled water jet cleaning, plastic bead blasting).

Grit and shot blasting are not suitable. Chemical cleaning agents, paint strippers, and solvents shall not be used unless it has been established that they would not have an adverse effect on the cylinder or its materials.

Care shall be taken not to remove any evidence of in-service damage (e.g. heat and fire damage), which could affect the outcome of this inspection (see Table 1).

Composite cylinders differ from their metal counterparts in that a competent person may repair them when only limited damage has taken place (see 7.4). These limits are defined in Table 1; following this repair, cylinders shall be subjected to a pressure test before being returned to service.

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7.2 Inspection procedures

The acceptance/rejection criteria given in Table 1 shall be followed as a minimum. The inspection body shall contact the cylinder manufacturer to establish whether there are less stringent rejection criteria for the particular cylinder design. In case of doubt, the inspection body shall make reference to the design drawing of the cylinder. Hoop-wrapped cylinders as well as those with exposed external metal surfaces, especially at the interface with the composite overwrap, shall be inspected in accordance with the applicable clauses of the relevant standard (i.e. ISO 6406 for steel cylinders and ISO 10461 for aluminium-alloy cylinders).

The external surface shall be inspected for damage to the composite overwrap. There are three levels of damage that shall be considered (see 7.3.3); of these, only two can be repaired (see Table 1).

7.3 Damage

7.3.1 General

Damage to the composite overwrap can appear in many forms, and examples of these are described in 7.3.3 to 7.3.4. The acceptance/rejection criteria are specified in Table 1, which refers to defined damage levels and the types of damage. Care shall be taken to establish the total extent of damage from impact (see 7.3.4.3) and delamination (see 7.3.4.4) as surface appearance might not indicate the full extent of the damage.

Annex A specifies additional damage criteria for steel wire wound, aluminium-alloy cylinders.

Whenever cylinder damage is discovered, the likely cause of the damage shall be investigated.

When damage is caused by installation (e.g. trailer or bundle), severity or conditions of service, or by improper cylinder use, the inspector should advise the cylinder owner of the need to take corrective action to prevent or reduce further cylinder damage, or to prevent damage to a replacement cylinder. Such actions should be developed with the manufacturer of the cylinder and the original installer.

7.3.2 Identification label

If the label is illegible, the manufacturer of the cylinder shall be contacted.

The manufacturer may only affix a supplementary identification label to the cylinder if, as a minimum, the original label's serial number is still clearly legible.

7.3.3 Damage levels

7.3.3.1 General

In the absence of acceptance criteria based upon testing, all Level 2 damage shall be identified as Level 3 damage. The surface of the cylinder shall be inspected for evidence of damage. Damage shall be evaluated in accordance with Table 1.

7.3.3.2 Level 1 damage

Cylinders with no external visual damage or minor damage are categorized as Level 1 damage and are acceptable, hence no repair is required. Such damage normally has no adverse effects on the safety of the cylinder and its continued use. Scratched paint or nicks that have no appreciable depth in metal, or similar damage in the composite cylinder paint or resin where there are no visible frayed fibres, are considered to be of this level of damage.

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7.3.3.3 Level 2 damage

Level 2 damage is rejectable damage that requires repair, testing, or rendering the cylinder unserviceable, as advised by the cylinder manufacturer. Level 2 damage is also reserved for conditions specified by the manufacturer, which can differ from Level 1 or Level 3 damage outlined in Table 1. Level 2 damage is either shown to be acceptable (Level 1) by the manufacturer's test and investigation results, or else evaluated to be Level 3.

7.3.3.4 Level 3 damage

Level 3 damage is sufficiently severe that the cylinder shall not be repaired, but shall be rejected and subsequently rendered unserviceable.

Table 1 — 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 to the following depth is acceptable: Less than 0,25 mm[a]	Damage greater than Level 1 but less than Level 3 shall be referred to the manufacturer for repair procedures.[b] Otherwise, the damage shall be considered Level 3. If the manufacturer does not provide repair instructions, the damage shall be considered Level 3.	Damage greater than: — 15 % of composite overwrap thickness for fully-wrapped cylinders; — 30 % of composite overwrap thickness for hoop-wrapped cylinders.
Impact damage	Damage from impact, which causes a frosted appearance or hairline cracking in the impact area that is less than 25 mm in diameter without permanent deformation, is acceptable.[b]	Damage greater than Level 1 shall be referred to the manufacturer for evaluation.[b] Otherwise, the damage shall be considered Level 3.	Damage from impact that causes permanent deformation (e.g. dent).
Delamination	No visible delamination	Loose fibre ends from the termination of the wrapping process shall be repaired.	Delaminating fibres not included in Level 2.
Heat or fire damage	When the composite overwrap is only soiled from smoke or other debris and is found to be suitable for further service.[b] Additional attention shall be given to cylinders with an aluminium-alloy liner/boss or a non-load sharing liner.	Damage greater than Level 1 no repair allowed – consider as Level 3.	Cylinders with evidence of heat or fire damage greater than Level 1 shall be rendered unserviceable.
Structural damage	When the cylinder is found to be suitable for further service [b]	No repair allowed	All cylinders

[a] The depth measurement starts at the surface of the cylinder, including coating if present, but excluding protective sleeves that are not part of the cylinder design.

[b] This needs to be established by further investigation.

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Table 1 *(continued)*

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)**
Chemical attack	When the cylinder is found to be suitable for further service [b]	If the chemical's nature is known, the cylinder manufacturer shall provide documentation confirming Level 1 or 2. If Level 2, the manufacturer shall suggest a suitable repair procedure.[b]	All cylinders if chemical unknown. Any attack of the fibre.
Missing/illegible identification label or markings	Not applicable	In the event that the manufacturer can unmistakably identify the cylinder, by at least the serial number, a new label shall be supplied by the manufacturer and affixed or the marks applied either by the inspection body or the manufacturer (see ISO 13769).	All cylinders that cannot be identified and relabelled/remarked.
Loose permanent attachments	Not applicable	Repair possible provided manufacturer gives written consent.	All cylinders other than those in Level 2
Improper repair	Not applicable	Following a repair (see 7.4), all defects can be repaired a second and final time; the cylinder shall be retested.	All cylinders with defects after the second repair.
Other damage (of a cosmetic nature)	— 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 with no appreciable depth	Not applicable Small groups of abraded fibres	Not applicable
Damaged permanent attachment	No damage or minor damage such as nicks, scratches consistent with normal wear	When dented, cracked, broken, showing other signs of damage (e.g. discolouration from impact) or as advised by the manufacturer. Permanent attachment to be removed and composite cylinder to be assessed for damage. New attachment may be fitted provided cylinder suitable for further service.	If Level 2 damage exists and replacement of the damaged attachment is not possible Or If the composite cylinder shows damage adjacent to a damaged area on the attachment

[a] The depth measurement starts at the surface of the cylinder, including coating if present, but excluding protective sleeves that are not part of the cylinder design.

[b] This needs to be established by further investigation.

7.3.4 Types of damage

7.3.4.1 Abrasion damage [see Figures 1a) to 1c)]

Abrasion damage is caused by wearing, grinding, or rubbing away by friction of the overwrap material. 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)].

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7.3.4.2 Damage from cuts [see Figures 2a) and 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.

7.3.4.3 Impact damage [see Figures 3a) and 3b)]

Impact damage can appear as hairline cracks in the resin, or delamination or cuts of the composite overwrap. The resin can have a frosted or smashed appearance.

7.3.4.4 Delamination (see Figure 4)

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

7.3.4.5 Heat or fire damage [see Figures 5a) and 5b)]

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

7.3.4.6 Structural damage

Structural damage is any evidence of bulges, distorted neck thread connections, depressions not originally designed, or if, by visual examination of the cylinder interior, there is evidence of damage involving deformation of the liner.

7.3.4.7 Chemical attack [see Figures 6a) and 6b)]

Chemical attack would appear as the dissolution of the matrix surrounding the fibres. The resulting cylinder surface can be pitted, feel soft/sticky, discoloured, etc.

7.3.4.8 Loose permanent attachments

Signs of a collar, neck ring or other permanent attachment that is part of the design becoming loose are causes for rejecting the cylinder.

7.3.4.9 Improper repairs

Signs of damage in the repaired area in excess of Level 1 are causes for rejecting the cylinder.

7.3.4.10 Damaged permanent attachment

Damage to permanent attachments, e.g. cage, outer casing, etc., excluding transparent sleeves (see 7.1.2), that are part of the original cylinder design is Level 3 damage unless the manufacturer provides an inspection manual of damage criteria based on experimental data.

7.4 Repairs

A resin system may be used to repair composite cylinders. Reference shall be made to the design drawing of the cylinder, 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 the 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. 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 a repair from a previous inspection shall not be repaired in the same area.

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Figures 7a) through 7e) illustrate the sequence of a typical repair procedure.

8 Internal visual inspection

8.1 Safe removal of valve

The cylinder's valve shall not be removed until it is verified that there is no pressure inside the cylinder. A valve in the open position does not guarantee that the cylinder is not pressurized. The procedures in ISO 25760 shall be followed for the safe removal of a valve.

8.2 Internal inspection and cleaning

8.2.1 General

The whole of the internal surface of each cylinder shall be inspected, using an adequate technique and illumination to identify any imperfections present. Annex B specifies additional internal inspection requirements for translucent cylinders.

8.2.2 Metallic liners

A cylinder that shows the presence of foreign matter, or signs of more than light surface corrosion, shall be cleaned internally under closely controlled conditions. Care shall be taken to avoid damaging the liner and composite materials.

8.2.2.1 Steel liners

Suitable cleaning methods such as shot-blasting, water jet abrasive cleaning, flailing, steam jet, hot water jet, rumbling, chemical cleaning, or others may be used. The method used to clean the cylinder shall be a validated, controlled process.

If the cylinder has been cleaned by one of the above methods, it shall be inspected after the cleaning operation in accordance with the relevant standard for liners (e.g. ISO 6406).

8.2.2.2 Aluminium-alloy liners

Suitable cleaning methods such as water jet abrasive cleaning, flailing, steam jet, hot water jet, chemical cleaning (see 8.2.3), blasting with glass beads, or others may be used. The method used to clean the cylinder shall be a validated, controlled process.

Cleaning with material other than aluminium or glass beads, etc. shall be avoided. Hard media can imbed itself in the aluminium. Alkaline solutions and paint strippers that are harmful to aluminium and its alloys shall not be used.

If the cylinder has been cleaned by one of the above methods, it shall be inspected after the cleaning operation in accordance with the relevant standard for liners (e.g. ISO 10461).

8.2.3 Linerless and non-metallic liners

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

A cylinder showing the presence of foreign matter, or signs of more than light surface corrosion/chemical attack, shall be cleaned internally under closely controlled conditions by controlled water jet abrasive cleaning or a method recommended by the manufacturer. Any cleaning methods and/or chemical solutions used for cleaning shall be 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 defect (i.e. heat damage, chemical attack, cracks, bulges, implosion) shall be leak tested (see Clause 10).

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Table 2 describes certain criteria to be followed in the absence of specific instructions from the manufacturer of the cylinder being examined. A substantial variety of liner materials and their associated designs exist, making a comprehensive and uniform description difficult to formulate within this International Standard. The inspector shall contact the manufacturer and obtain any specific instructions. In any case, the criteria listed in Table 2 are more stringent than the design can require.

Table 2 — Description of damage levels for various types of imperfections

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)**
Bulge inward or outward	None	Not allowed	Any
Cracking	None	Not allowed	Any
Indications of chemical attack	None or passed leak test	If chemical is identified and not adversely affecting internal materials, can be cleaned out and dried. Shall be leak tested.	Not leak tested or failed leak test or chemical is unidentified Or Chemical identified and is not compatible with the internal materials
Indications of melting	None	Not allowed	Any
Presence of liquid/chemical material	None or passed leak test	If liquid/chemical is identified and not adversely affecting internal materials, can be cleaned out and dried. Must be leak tested.	Not leak tested or failed leak test or liquid/chemical is unidentified Or Liquid/chemical identified and is not compatible with the internal materials
Discoloured interior	None or known to be non-consequential	If discoloration is from a known source that does not affect cylinder safety or performance, then can be removed if possible or Level 1. Can be leak tested if discoloration is from unknown source.	Any reason for discolouration that adversely affects cylinder safety and/or performance. Not leak tested or failed leak test.
Composite matrix (no liner) shows deterioration and/or loose fibres	None or minor confirmed to pass leak test	A few strands noted or doubtful, then must pass leak test	Not leak tested or failed leak test, or when deterioration is extensive
Crease	None	Not allowed	Any
Excess resin droplets (no liner only)	None or identified as excess resin	Not applicable (no need to repair)	Not applicable

8.3 Inspection of cylinder neck/shoulder

The neck threads (valve connections) and the shoulder of the cylinder shall be inspected in accordance with ISO 6406 for steel cylinders or ISO 10461 for aluminium-alloy cylinders.

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9 Pressure test

Each cylinder shall be subjected to a proof pressure test using a suitable fluid, normally water, as the test medium. The testing medium used shall not reduce the integrity of the cylinder.

All types of composite cylinders covered by this International Standard shall be tested in accordance with the relevant standard for liners (e.g. ISO 6406 for steel cylinders or ISO 10461 for aluminium-alloy cylinders). The test pressure shall be established from the marking on the cylinder.

In the case when a pneumatic pressure test is carried out, appropriate measures should be taken to ensure safe operation and to contain any energy that can be released.

Adequate safety precautions shall be taken during the test. Any cylinder failing to conform to the requirements of this test shall be rejected.

10 Leak test

Leak tests shall be performed when indicated by the nature of the imperfections found during the internal inspection as noted in Table 2. The following method is an example for leak testing and is recommended, but alternatives which achieve the same result are permitted.

— Pressurize the cylinder to 2/3 of the test pressure with a gas compatible with the previous contents and liner. In most cases, this could be air or nitrogen;

— Maintain this pressure in the cylinder for not less than 2 h; and

— Conduct a bubble leak test for at least 10 min. The cylinder shall be visually checked for leaks using a suitable technique (e.g. with soapy water, cylinder immersion).

Leakage greater than 1 bubble/min, i.e. 6 ml/h in the bubble leak test, shall constitute a failure of the cylinder.

Adequate safety precautions should be taken to contain any energy that can be released.

11 Inspection of valve

If a valve is to be reintroduced into service, it shall be inspected to ensure that it performs satisfactorily and to confirm gas tightness (see ISO 22434).

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 to remove all traces of free water. The interior of the cylinder shall be inspected to ensure that it is dry and free from other contaminants. If heat is used for drying, care shall be taken to ensure that the maximum time and temperature as indicated in 5.2 are not exceeded.

12.2 Painting

In general, composite cylinders are not required to have their original paint renewed. When repainting is undertaken, it shall be carried out with great care to ensure that no damage is caused to any of the composite surfaces when the original paint has to be removed. 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 manufacturers be contacted for appropriate painting procedures for their cylinders.

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Care shall be taken that the identification label is masked out prior to painting to maintain its legibility.

12.3 Cylinder re-valving

If re-valving is required after the pressure test, the neck thread shall be reinspected in accordance with 8.3 before the cylinder is re-valved to verify absence of damage.

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 for the most common ISO thread sizes unless contrary information is shown on the label. (For other threads, see ISO/TR 11364.)

When 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

These requirements shall apply only to cylinders for liquefied gases and compressed gases filled by weight. The tare weight of the cylinders shall be obtained using a weighing machine that is regularly calibrated and checked for accuracy. The capacity of the weighing machine shall be suitable for the weight of the appropriate cylinders.

The tare shall include the mass of the cylinder, valve(s), and all permanent attachments. If the tare of the cylinder differs from the marked tare by more than the value shown in Table 3 and is not due to damage, the original tare shall be cancelled and the correct tare marked in a permanent and legible fashion in accordance with ISO 13769.

NOTE 1 The weight of the paint on the cylinder is not included in the tare weight marked on the cylinder by the manufacturer.

NOTE 2 Cylinders of water capacity greater than 80 l might need a different maximum allowable deviation in their tare weight

Table 3 — Allowable deviation in cylinder tare weight

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

12.5 Marking

After satisfactory completion of the periodic inspection and testing, each cylinder shall be permanently marked or labelled in accordance with ISO 13769 with the present test date, followed by the symbol of the authorized body carrying out the inspection (inspection body or testing facility).

For taper threaded cylinders, the above information may be indicated on a metal ring that is trapped between the valve and the cylinder neck.

NOTE Attention is drawn to requirements for marking in relevant regulations which might override the requirements given in ISO 13769.

12.6 Reference to next test date

When required, the next test date shall be shown by an appropriate method (e.g. a plastic disc fitted between the valve and the cylinder) indicating the date (year as YYYY) of the next periodic inspection test.

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12.7 Identification of contents

When required by the cylinder owner/operator, the inspector shall affix a label to identify the cylinder contents in accordance with ISO 7225 and colour code the cylinder in accordance with ISO 32.

If painting is required, care shall be exercised in accordance with 12.2.

If a change of gas service is involved, follow the requirements of ISO 11621.

12.8 Records

The testing facility shall record details of the present test and the following information shall be available:

— owner's name;

— owner's and/or manufacturer's serial number;

— cylinder tare where applicable;

— test pressure;

— present test date;

— identification symbol of the authorized body carrying out the inspection (inspection body or testing facility);

— identification of inspector; and

— 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 in a single file but will enable a particular cylinder to be traced. These items are:

— cylinder manufacturer;

— manufacturing specification; and

— nominal water capacity.

All information regarding the test shall be retained by the testing facility and shall be available for a minimum of two periodic inspection and testing intervals.

13 Rejection and rendering cylinders unserviceable

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

In case of any disagreement, the legal implications of the contemplated action should be fully understood.

One of the following methods shall be used to render the cylinder unserviceable:

— crushing the cylinder using mechanical means;

— cutting the neck off the cylinder;

— cutting of the cylinder in two or more irregular pieces; or

— hydraulically pressurizing the cylinder to failure.

Care shall be taken to ensure that the method used does not create an environmental hazard. Furthermore, care shall be taken to ensure that the method used is carried out in a safe manner.

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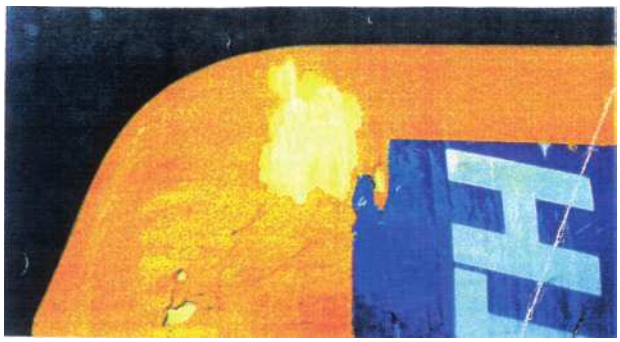
a) Level 1 abrasion damage — Superficial abrasion



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

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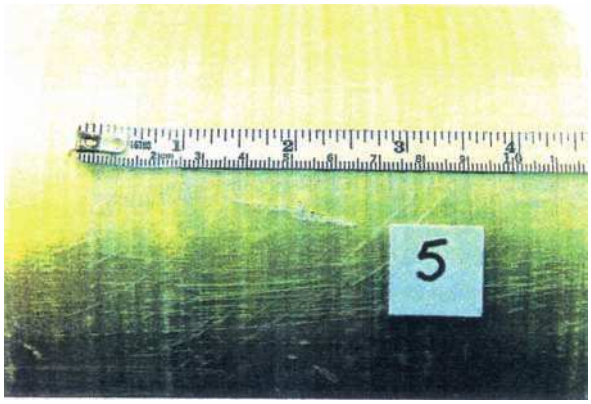
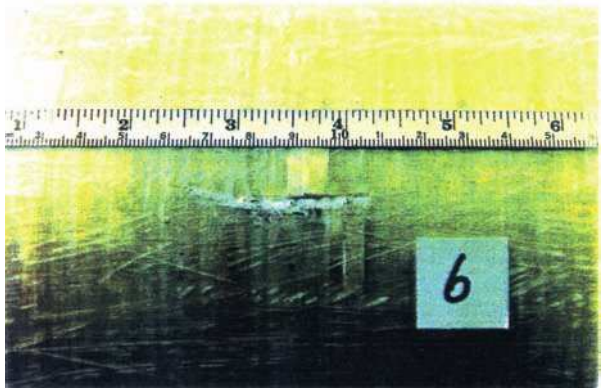


a) Level 1 damage from cuts — Superficial cut



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

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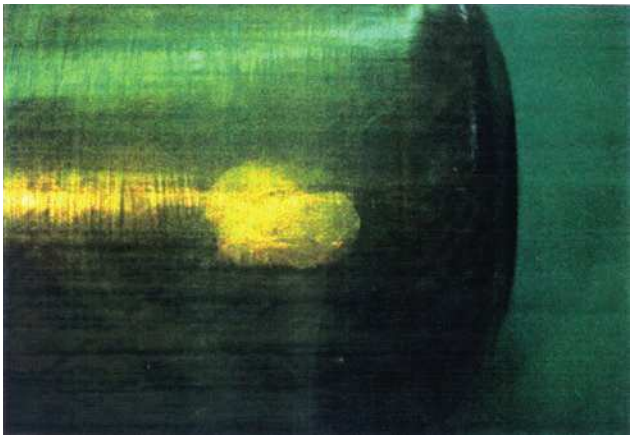

b) Level 3 impact damage — Depth of damage over 15 % of thickness (fully-wrapped cylinder)

Figure 3 — Impact damage

Figure 4 — Delamination

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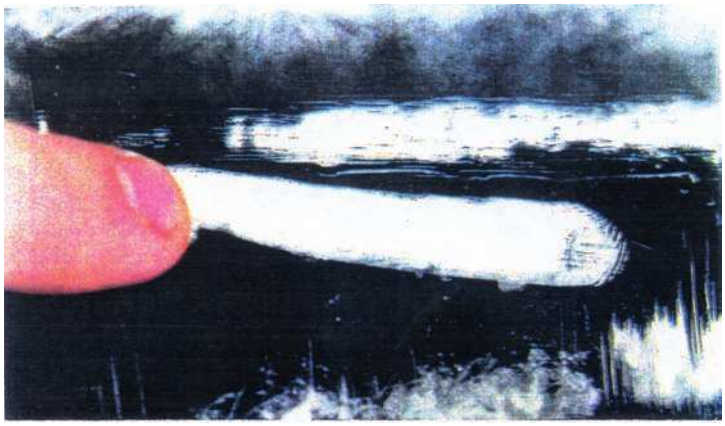

a) Level 1 fire damage — Surface charring only

b) Level 3 fire damage

Figure 5 — Heat or fire damage

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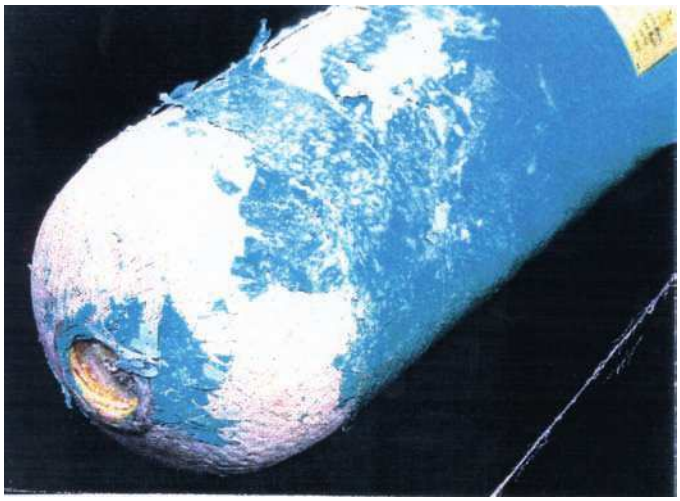
a) Chemical damage (other than paint stripper)



b) Chemical damage (24 h in paint stripper)

Figure 6 — Chemical attack damage

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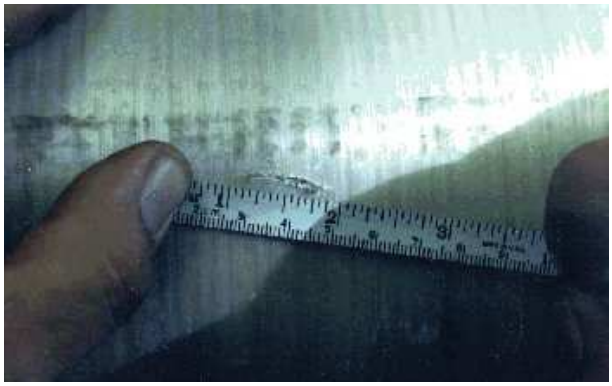
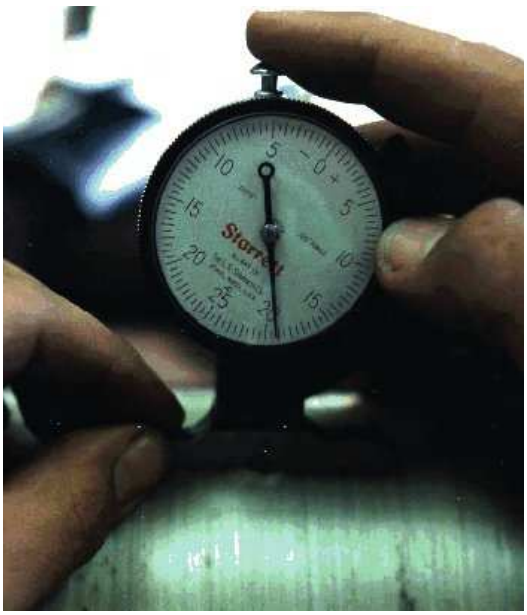


a) Length measurement



b) Depth measurement

c) Resin mixing

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d) Resin application

e) After cure

Figure 7 — Typical repair procedure

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Annex A
(normative)

Damage criteria for steel wire wound, aluminium-alloy cylinders

Annex A provides specific damage criteria in addition to those described in 7.3.

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

The specific criteria are the following:

a) **Corrosion damage**:

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

Slight corrosion of the steel wire can 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 shall be categorised as Level 3.

b) **Loosening of steel wire**:

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

All such types of failure shall be categorised as Level 3.

c) **Failure of aluminium retainers at the ends**:

The steel wires are kept in position by aluminium retainers. Mishandling or corrosion can force the retainers to be dislodged. This type of failure can be detected visually. All such types of failure shall be categorised as Level 3.

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Annex B
(normative)

Internal inspection of translucent cylinders

B.1 All translucent cylinder types

For translucent cylinders with known content/gas service, following an assessment that confirms that the internal cylinder material, e.g. liner or composite wrapping, does not degrade from exposure to any of the substances in the gas (including all potential contaminants), then an internal inspection is not necessary. Such an assessment shall be made by a chemical resistance test of the cylinder to all substances contained in the gas used. Any kind of potential contaminants also shall be investigated in the same manner.

B.2 Translucent cylinders with permanent protective attachment

For translucent cylinders with a permanent protective attachment, allowing direct or indirect inspection of the entire internal surface of the cylinder, either linerless with translucent composite wrapping or cylinders with translucent liner and wrapping, an internal inspection can be performed from the outside provided that internal damage such as that described in Table 2 can be detected.

It shall be verified that damage according to Table 2 and foreign matter may be identified through the cylinder wall. In order to aid inspection, a light source may be used to highlight damage

An internal inspection shall be performed if any discolouration of the resin is present.

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Annex C
(informative)

Intervals between periodic inspection and testing

Retest periods are normally specified in the applicable regulations (e.g. UN *Model Regulations*, P200). However, composite cylinders are subject to decisions by the competent authority in the country of use. The following tables give guidance for the retest periods for those countries where regulations for retest periods do not exist.

Table C.1 — Intervals for aluminium-alloy liners[a]

Gas service	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[b,d]
Liquefied gases	e.g. CO_2, N_2O, and liquefied gas mixtures	
Very toxic gases $LC_{50} \leq 200$ ppm V/V	e.g. AsH_3, PH_3	3

[a] Certain requirements can necessitate a shorter time interval, e.g. presence of mercury in hydrogen, polymerisation, and decomposition reactions. The compatibility of the gas 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 retest period shall not exceed 5 years.

[c] This list of gases is not exhaustive. Gases shall be categorised in accordance with ISO 10298.

[d] 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. Reference shall be made to the manufacturer or inspection body if there is a question on the retest period for specific gases.

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Table C.2 — Intervals for steel liners[a]

Gas service	Gas[g]	Period (Years)
Compressed gases	e.g. Ar, Xe, Ne, N_2, CH_4, and compressed gas mixtures	5 or 10[f]
	H_2	5 or 10[e,f]
	Air, O_2	5 or 10[b,f]
	CO	2,5 or 5[d]
Underwater breathing apparatus	Air, O_2	2,5 (visual) and 5 (full)
Liquefied gases	e.g. CO_2, N_2O and liquefied gas mixtures	5 or 10[c,f]
Corrosive gases (to cylinder material)	e.g. Cl_2, F_2, NO, SO_2, HF	3
Very toxic gases $LC_{50} \leq 200$ ppm V/V	e.g. AsH_3, PH_3	3
Gas mixtures	a) All mixtures except those containing very toxic gases	a) Shortest period of any component
	b) Mixtures containing very toxic gases	b) If the toxicity of the final mixture is such that $LC_{50} > 200$ ppm V/V, a 5- or 10-year period shall apply[f]. If the toxicity of the final mixture is such that $LC_{50} \leq 200$ ppm V/V, a three-year period shall apply.

[a] Certain requirements can 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 the gas with steel shall be checked in accordance with ISO 11114-1.

[b] For cylinders used for underwater applications and self-contained breathing apparatus, the retest period shall not exceed 5 years.

[c] The longer test period can 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 5 years and fully retested every 10 years.

[d] The longer test period can 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 these conditions cannot be fulfilled, the cylinder shall be visually and internally inspected every 2,5 years and fully retested every 5 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 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 categorised in accordance with ISO 10298.

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Table C.3 — Intervals for non-metallic liners[a]

Gas service	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[b,e]
Liquefied gases	e.g. CO_2, N_2O, and liquefied gas mixtures	
Very toxic gases $LC_{50} \leq 200$ ppm V/V	e.g. AsH_3, PH_3	3[c,e]

[a] Certain requirements can necessitate a shorter time interval, e.g. presence of mercury in hydrogen, polymerisation, and decomposition reactions. The compatibility of the gas 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 retest period shall not exceed 5 years.

[c] For mixtures involving these gases, if the toxicity of the final product $LC_{50} > 200$ ppm V/V, a 5- or 10-year period shall apply[e].

[d] This list of gases is not exhaustive. Gases shall be categorised in accordance with ISO 10298.

[e] 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.

Table C.4 — Cylinders without liners[a]

Gas service[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[b,d]
Liquefied gases	e.g. CO_2, N_2O and liquefied gas mixtures	

[a] Certain requirements can necessitate a shorter time interval, e.g. presence of mercury in hydrogen, polymerisation, and decomposition reactions. The compatibility of the gas 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 retest period shall not exceed 5 years.

[c] This list of gases is not exhaustive. Gases shall be categorised in accordance with ISO 10298.

[d] 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.

[e] Very toxic gases shall not be filled into this type of cylinder.

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