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Gas cylinders — Welded carbon-steel gas cylinders — Periodic inspection and testing

Bouteilles à gaz — Bouteilles à gaz soudées en acier au carbone — Contrôles et essais périodiques

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Contents

Page

Foreword ... iv
Introduction ... v
1 Scope ... 1
2 Normative references ... 1
3 Intervals between periodic inspections and tests ... 1
4 List of procedures for periodic inspections and tests ... 2
5 Identification of cylinder and preparation for inspections and tests ... 2
6 Depressurization and de-valving procedures ... 3
7 External visual inspection ... 3
8 Internal visual inspection ... 4
9 Supplementary tests ... 4
10 Inspection of cylinder neck ... 4
11 Pressure test ... 5
12 Repair of cylinders ... 6
13 Inspection of valve and other accessories ... 6
14 Final operations ... 6
15 Rejection and rendering cylinders unserviceable ... 9
Annex A (informative) **Intervals between periodic inspections and tests** ... 10
Annex B (informative) **List of gases corrosive to cylinder material** ... 11
Annex C (normative) **Description and evaluation of defects and conditions for rejection of welded carbon-steel gas cylinders at time of visual inspection** ... 12
Annex D (normative) **Procedure to be adopted when de-valving and/or when it is suspected that a cylinder valve is obstructed** ... 16
Annex E (informative) **Inspection and maintenance of valves and their junctions: recommended procedures** ... 19
Annex F (informative) **Test date rings for gas cylinders** ... 20
Bibliography ... 21

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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 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10460 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders*.

This second edition cancels and replaces the first edition (ISO 10460:1993), which has been technically revised.

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Introduction

The principal aim of a periodic inspection and testing procedure is to be satisfied that at the completion of the test the cylinders can be re-introduced into service for a further period of time.

The inspection and test are to be carried out only by persons who are authorized under the relevant regulations and competent in the subject to assure all concerned that the cylinders are fit for continued safe use.

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

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Gas cylinders — Welded carbon-steel gas cylinders — Periodic inspection and testing

1 Scope

This International Standard deals with welded, carbon-steel, transportable gas cylinders intended for compressed and liquefied gases under pressure, of water capacity from 0,5 l to 150 l; it also applies, as far as practical, to cylinders of less than 0,5 l water capacity and greater than 150 l up to 450 l.

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

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

This International Standard is primarily for industrial gases other than liquefied petroleum gas (LPG), but may also be applied for LPG. For specific LPG applications, see ISO 10464.

2 Normative references

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

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

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

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

3 Intervals between periodic inspections and tests

A cylinder shall be due for a periodic inspection and test on its first receipt by a filler after the expiry of the interval in accordance with the requirements of the United Nations *Recommendations on the Transport of Dangerous Goods, Model Regulations* or as specified by national or international authorities (see examples in Annex A).

Provided the cylinder has been subjected to normal conditions of use and has not been subjected to abusive and abnormal conditions rendering the cylinder unsafe, there is no general requirement for the user to return a gas cylinder before the contents have been used even though the periodic inspection and test interval may have lapsed.

It is the responsibility of the owner or user to submit the cylinder for a periodic inspection and test within the interval specified by national or international authorities, or as specified in the relevant cylinder design standard if this is shorter.

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4 List of procedures for periodic inspections and tests

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

a) identification of cylinder and preparation for inspections and tests (Clause 5);

b) depressurization and de-valving procedures (Clause 6);

c) external visual inspection (Clause 7);

d) internal visual inspection (Clause 8);

e) supplementary tests (Clause 9);

f) inspection of cylinder neck (Clause 10);

g) pressure test (Clause 11);

h) repair of cylinders (Clause 12);

i) inspection of valve and other accessories (Clause 13);

j) final operations (Clause 14);

k) rejection and rendering cylinders unserviceable (Clause 15).

It is recommended that the previously listed tests be performed in the suggested sequence. In particular the internal visual inspection (Clause 8) should be carried out before the pressure test (Clause 11).

Cylinders that fail an inspection or tests shall be rejected (see Clause 15). Where a cylinder passes the above procedures, but when the condition of the cylinder remains in doubt, additional tests shall be performed to confirm its suitability for continued service or the cylinder shall be rendered unserviceable.

Depending on the reason for the rejection, some cylinders may be recovered (see Clause 8, 10.3 and Annex C).

The inspections and tests shall be carried out only by persons who are competent in the subject and authorized under relevant regulations.

Mechanical properties of steel cylinders can be affected by heat. Therefore, the maximum temperature for any operation shall be limited according to the manufacturer's recommendations.

5 Identification of cylinder and preparation for inspections and tests

Before any work is carried out, the relevant cylinder data (e.g. see ISO 13769) and its contents and ownership shall be identified. Cylinders with incorrect or illegible markings, unknown gas contents or those that cannot be safely emptied of gas shall be set aside for special handling.

If contents are identified as hydrogen or other embrittling gases, only those cylinders manufactured or qualified as hydrogen cylinders shall be used for that service. It shall be checked that the cylinder is compatible for hydrogen service, i.e. with respect to the maximum tensile strength and internal surface condition. For example, cylinders according to ISO 13769 are stamped “H”. All other cylinders shall be withdrawn from hydrogen service and their suitability checked for their new intended service.

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6 Depressurization and de-valving procedures

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

Before removing any pressure-retaining accessory (valve, flange, etc.), a positive check shall be performed to ensure that the cylinder does not contain any gas under pressure. This can be performed as described in Annex D using a device such as shown in Figure D.1.

Cylinders with inoperative or blocked valves shall be treated as outlined in Annex D.

Provided the requirements previously stated have been complied with, the cylinder shall be depressurized safely and the valve shall be removed.

7 External visual inspection

7.1 Preparation for external visual inspection

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

If fused nylon, polyethylene or a similar coating has been applied and the coating is seen to be damaged or prevents a proper inspection, then the coating shall be stripped. If the coating has been removed by the application of heat, in no case shall the temperature of the cylinder have exceeded 300 °C.

7.2 Inspection procedure

The external surface of each cylinder shall then be inspected for

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

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

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

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

e) integrity of all permanent attachments (see C.2); and

f) vertical stability, if relevant (see Table C.1).

When inspecting for corrosion [see c)], special attention shall be given to areas where water could be trapped. These include the entire base area, the junction between the body and the foot-ring and the junction between body and the shroud.

For rejection criteria, see Annex C. Cylinders no longer suitable for future service shall be rendered unserviceable (see Clause 15).

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8 Internal visual inspection

Each cylinder shall be inspected internally using adequate illumination to identify any defects similar to those listed in 7.2 a) and 7.2 c). Precautions shall be taken to ensure that the method of illumination presents no risks to the tester while performing the operation. Any internal liner or coating that may obstruct optimum internal visual inspection shall be removed. Any cylinder showing presence of foreign matter or signs of more than light surface corrosion shall be cleaned internally under closely controlled conditions by shot-blasting, water jet abrasive cleaning, flailing, steam jet, hot water jet, rumbling, chemical cleaning or other suitable method. The method used to clean the cylinder shall be a validated, controlled process. Care shall be taken at all times to avoid damaging the cylinder or removing excess amounts of cylinder wall (see Annex C). If cleaning is required, the cylinder shall be reinspected after the cleaning operation.

9 Supplementary tests

Where there is doubt concerning the type and/or severity of a defect found on visual inspection, additional tests or methods of examination shall be applied, e.g. ultrasonic techniques, check weighing or other non-destructive tests.

10 Inspection of cylinder neck

10.1 Cylinder to valve threads

When the valve is removed, the cylinder to valve threads shall be examined to identify the type of thread (e.g. 25E) and to ensure that they are

— clean and of full form,

— free of damage,

— free of burrs,

— free of cracks, and

— free of other imperfections.

10.2 Other neck surfaces

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

10.3 Damaged internal neck threads

Where necessary and where the manufacturer or the competent design authority confirms that the design of the neck permits, threads may be re-tapped or the thread type changed to provide the appropriate number of effective threads. After re-tapping or changing the thread form, the threads shall be checked with the appropriate thread gauge, e.g. ISO 11191 for 25E threads.

10.4 Neck ring and collar attachment

When a neck ring/collar is attached, an examination shall be carried out to ensure it is secure and to inspect for thread damage. A neck ring shall only be changed using an approved procedure. If it is found that any significant damage to cylinder material has occurred by replacement of the neck ring/collar, the cylinder shall be rendered unserviceable (see Clause 15).

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11 Pressure test

11.1 General

Each cylinder shall be subjected to a hydraulic or pneumatic pressure test.

WARNING — Appropriate measures shall be taken to ensure safe operation and to contain any energy that could be released. It should be noted that pneumatic pressure tests require more precautions than hydraulic pressure tests since, regardless of the size of the container, any error in carrying out this test is highly likely to lead to a rupture under gas pressure. Therefore, these tests shall be carried out only after ensuring that the safety measures satisfy the safety requirements.

Each cylinder subjected to a hydraulic pressure test shall use a suitable fluid, normally water, as the test medium. The test pressure shall be established from the stamping on the cylinder.

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

The following proposes a typical method for carrying out the test. Any cylinder failing to comply with the requirements of a hydraulic proof pressure test shall be rendered unserviceable.

11.2 Test equipment

11.2.1 All rigid pipe work, flexible tubing, valves, fittings and components forming the pressure system of the test equipment shall be designed to withstand a pressure at least 1,5 times the maximum test pressure of any cylinder that could be tested.

11.2.2 Pressure gauges shall be to Industrial Class 1 (± 1 % deviation from the end value) with a scale appropriate to the test pressure (e.g. EN 837-1 or EN 837-3). They shall be checked for accuracy against a calibrated master gauge at regular intervals and in any case not less than once a month. The master gauge shall be calibrated in accordance with national requirements. The pressure gauge shall be chosen so that the test pressure is between approximately one-third and two-thirds of the value capable of being measured on the pressure gauge.

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

11.2.4 All joints within the system shall be leak tight.

11.2.5 A suitable system control device shall be fitted to the test equipment to ensure that no cylinder is subjected to a pressure in excess of its test pressure by more than the tolerances specified in 11.3.3.

11.3 Test criteria

11.3.1 More than one cylinder may be tested at a time provided that they all have the same test pressure. If individual test points are not used, then in case of leakage all cylinders being tested shall be individually re-tested.

11.3.2 Before applying pressure, the external surface of the cylinder shall be dry.

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

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

11.3.5 If there is a leakage in the pressure system, it shall be corrected and the cylinders retested.

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11.4 Acceptance criteria

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

There shall be absence of visible leakage on the entire surface of the cylinder. This check can be made during the 30 s hold. There shall be no visible permanent deformation.

12 Repair of cylinders

12.1 Repair of pinholes

If during the pressure test or external visual inspections pinhole leaks are detected in a weld, the cylinder shall be made unserviceable or repaired by welding (see 12.3.1). No other repair to pressure containing welds shall be undertaken.

12.2 Other repairs

Any other major repairs, including removal of dents and replacement of foot-rings and shrouds, can be carried out provided this repair will not impair the integrity of the cylinder. All corrosion product shall be removed prior to repair.

12.3 Requirements for repair

12.3.1 Repairs as defined in 12.1 and 12.2 shall be performed to the original manufacturer's heat treatment procedure by a competent/authorized reconditioner following an approved procedure and taking into account the fabrication and testing requirements of the cylinder design standard. After such repairs, a stress relief/normalizing heat treatment shall be performed. The cylinder shall finally be hydraulically tested in accordance with Clause 11 and inspected as necessary for the intended gas service.

12.3.2 Minor repairs such as reforming damaged shrouds, carrying handles, etc., not involving welding or hot-work on pressure containing parts may be carried out as long as the integrity of the cylinder is not impaired.

12.3.3 Any operation that could result in loss of wall thickness to below minimum guaranteed wall thickness shall be completed before the inspection and testing procedures (see Annex C).

13 Inspection of valve and other accessories

If a valve or any other accessory is to be reintroduced into service, it shall be inspected and maintained to ensure that it will perform satisfactorily in service and meet the requirements of gas tightness from the valve manufacturing standards, e.g. ISO 10297. An example of a suitable method is given in Annex E.

14 Final operations

14.1 Drying, cleaning, painting and coating

14.1.1 Drying and cleaning

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

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14.1.2 Painting and coating

Cylinders are sometimes repainted using paints that require stoving. Plastic coatings may also be reapplied. Painting or coating shall be applied so that all the markings stamped on the cylinder remain legible.

In no case shall the temperature of the cylinder exceed 300 °C since overheating could change the mechanical properties of the cylinder.

14.2 Re-valving of the cylinder

Before re-valving the cylinder, the thread type shall be identified. The appropriate valve shall be fitted 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 material used according to the manufacturer's recommendations. Where the use of lubricants/sealing material is permitted, only those approved for the gas service shall be used, taking particular care for oxygen service in accordance with ISO 11114-2.

14.3 Check on cylinder tare

The requirement shall apply only to cylinders for liquefied gases. The tare of the cylinders shall be obtained by weighing on a scale calibrated with traceability to national or international standards. The weigh scale shall be checked for accuracy on a daily basis. The capacity of the weighing scale 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 stamped tare by more than the value shown in Table 1 and is not due to damage, the original tare shall be cancelled. For welded steel cylinders, particular attention shall be paid to the tare weight when replacing any valves, dip tubes, guards/shrouds and foot-rings. The new correct tare shall be marked in a durable and legible fashion (see ISO 13769).

Table 1 — Permissible deviation in tare

Cylinder water capacity, V l	Maximum permissible deviation in tare g
$0{,}5 \leqslant V < 5{,}0$	± 50
$5{,}0 \leqslant V \leqslant 20$	± 200
$V > 20$	± 400

14.4 Retest marking

14.4.1 General

After satisfactory completion of the periodic inspection and test, each cylinder shall be permanently marked according to the relevant standard or regulation, e.g. ISO 13769, with

a) the symbol of the inspection body or test station, followed by

b) the present test date.

14.4.2 Retester symbol and retest date

The retester symbol is the symbol of the inspection body or test station. The retest date is the date of the present test, which shall be indicated by the year and month.

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14.4.3 Stamping

These marks shall be in accordance with the relevant standard or regulations, e.g. ISO 13769.

14.5 Reference to next inspection and test date

When regulations require, the next inspection and 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 inspections and/or tests. Annex F provides one example of an existing system for indicating retest dates. Other systems are in use.

14.6 Identification of contents

Before the cylinder is reintroduced into service, the intended contents shall be identified. This need not be part of the periodic inspection and test procedure. As an example, use ISO 7225 and ISO 32. If painting is required, care shall be exercised in accordance with 14.1.2. If a change of gas service is involved, care shall be taken to follow the requirements of ISO 11621.

14.7 Records

A cylinder retest shall be recorded by the test station and the following information shall be available:

a) owner's name;

b) manufacturer's or owner's serial number;

c) cylinder mass (empty weight), or tare, where applicable;

d) type of test performed;

e) test pressure;

f) result of test (pass or fail);

g) present retest date — year/month/day;

h) identification symbol of the retest body or the test station;

i) identification of retester;

j) details of any repairs as described in Annex C made to the cylinder.

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 uniquely traced:

k) cylinder manufacturer's name;

l) manufacturer's serial number;

m) manufacturing design specification;

n) water capacity/size; and

o) manufacturing test date.

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15 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 impossible to recover a rejected cylinder, it shall, after notifying the owner, be made unserviceable by the testing station for holding gas under pressure so that it is impossible for any part of the cylinder, especially the shoulder, to be re-issued into service. In case of any disagreement, ensure that the legal implication of the contemplated action is fully understood.

Prior to taking any of the following actions, ensure that the cylinder is empty (see Clause 6).

The following methods may be employed:

a) crushing the cylinder using mechanical means;

b) burning an irregular hole in the top dome equivalent in area to approximately 10 % of the area of the top dome or, in the case of a thin-walled cylinder, by piercing in at least three places;

c) irregular cutting of the neck;

d) irregular cutting of the cylinder in two or more pieces including the shoulder; or

e) bursting using a safe method.

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Annex A
(informative)

Intervals between periodic inspections and tests

The following information includes intervals as outlined in the United Nations *Recommendations on the Transport of Dangerous Goods, Model Regulations,* thirteenth edition. The most current edition should be consulted.

Table A.1 — Intervals between periodic inspections and testing

Gas type	Examples	UN recommended interval years
Compressed gases	Ar, N_2, He	10
	H_2 [a]	10
	air, O_2	10
	self-contained breathing air, O_2	[b]
	gases for underwater breathing apparatus	[b]
	CO [c]	5
Liquefied gases	refrigerants, CO_2, liquefied petroleum gas	10
Corrosive gases	[d]	5
Toxic gases that are non-corrosive	sulphuryl fluoride	5
Very toxic gases that are non-corrosive	arsine (AsH_3), phosphine (PH_3)	5
Gas mixtures	all mixtures	5 or 10 years according to dangerous properties. Generally, mixtures that are toxic or corrosive have a 5-year interval, and other mixtures have a 10-year interval.

NOTE 1 These test periods 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 a quality system of the filler. If these conditions cannot be fulfilled, alternative or more frequent testing could be appropriate.

NOTE 2 At all times certain requirements may necessitate a shorter time interval, e.g. the dew point of the gas, polymerization reactions and decomposition reactions, cylinder design specifications, change of gas service, etc.

a Particular attention shall be paid to the tensile strength and surface condition of such cylinders. Cylinders not in conformance with the special hydrogen requirements shall be withdrawn from hydrogen service. See ISO 11621 for possible additional testing.

b Local regulations will specify the interval between periodic inspections.

c This product requires very dry gas. See ISO 11114-1:1997.

d Corrosivity is with reference to human tissue (see ISO 13338) and NOT cylinder material as indicated in Annex B.

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Annex B
(informative)

List of gases corrosive to cylinder material

Table B.1 — Gases corrosive to cylinder material

Gas name	Chemical formula	UN class or division	Subsidiary risk
Boron trichloride	BCl_3	2.3	8
Boron trifluoride	BF_3	2.3	8
Chlorine	Cl_2	2.3	8
Dichlorosilane	SiH_2Cl_2	2.3	2.1, 8
Fluorine	F_2	2.3	5.1, 8
Hydrogen bromide	HBr	2.3	8
Hydrogen chloride	HCl	2.3	8
Hydrogen cyanide	HCN	6.1	3
Hydrogen fluoride	HF	8	6.1
Hydrogen iodide	HI	2.3	8
Methylbromide	CH_3 Br (R40B1)	2.3	
Nitric oxide	NO	2.3	5.1, 8
Nitrogen dioxide	N_2O_4	2.3	5.1, 8
Phosgene	$COCl_2$	2.3	8
Silicon tetrachloride	$SiCl_4$	8	
Silicon tetrafluoride	SiF_4	2.3	8
Sulphur tetrafluoride	SF_4	2.3	8
Trichlorosilane	$SiHCl_3$	4.3	3, 8
Tungsten hexafluoride	WF_6	2.3	8
Vinyl bromide	CH_2: CHBr (R1140B1)	2.1	
Vinyl chloride	CH_2: CHCl (R1140)	2.1	
Vinyl fluoride	C_2H_3F (R1141)	2.1	

NOTE 1 These gases in a pure form are recognized to be potentially corrosive to low alloy steels in ISO 11114-1:1997 (see Tables 4, 6, 8, 9, 10 and 11).

NOTE 2 Mixtures containing these gases may not be corrosive.

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Annex C
(normative)

Description and evaluation of defects and conditions for rejection of welded carbon-steel gas cylinders at time of visual inspection

C.1 General

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

The object of this annex is to give general guidelines to gas cylinder users as to the application of rejection criteria, in particular, in case of lack of practical experience.

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

Any defect in the form of a sharp notch may be removed by grinding, machining or other approved methods. After such a repair, the wall thickness shall be checked, e.g. ultrasonically.

C.2 Physical or material defects

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

Permanent attachments (e.g. foot-rings or shrouds) shall be inspected and shall be suitable for these intended purposes.

C.3 Corrosion

C.3.1 General

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

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

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

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

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

Type of defect	Definition	Rejection limits in accordance with Clause 7 [a]	Repair or render unserviceable
Bulge	Visible swelling of the cylinder	All cylinders with such a defect	Render unserviceable
Dent	A depression in the cylinder that has neither penetrated nor removed metal and is greater in depth than 1 % of the outside diameter	When the depth of the dent exceeds 3 % of the external diameter of the cylinder or when the diameter of the dent is less than 15 times its depth	Render unserviceable Render unserviceable
Cut or gouge	A sharp impression where metal has been removed or redistributed (see Figure C.1) and whose depth exceeds 5 % of the cylinder wall thickness	When the depth of the cut or gouge exceeds 10 % of the wall thickness or when the length exceeds 25 % of the outside diameter of the cylinder or when the wall thickness is less than the minimum guaranteed wall thickness	Repair possible [b] Repair possible [b] Render unserviceable
Crack	A split or rift in the metal (see Figure C.2)	All cylinders with such defects	Render unserviceable
Fire damage	Excessive general or localized heating of cylinder usually indicated by a) partial melting of cylinder; b) distortion of cylinder; c) charring or burning of paint; d) fire damage to valve, melting of plastic guard or date ring.	All cylinders in categories a) and b) All cylinders in categories c) and d) may be acceptable after inspection and testing	Render unserviceable Repair possible
Plug or neck inserts	Additional inserts fitted in the cylinder neck, base or wall	All cylinders unless it can be clearly established that addition is part of approved design	Repair possible
Stamping	Marking by means of a metal punch	All cylinders with illegible, modified or incorrect markings	Render unserviceable [c]
Arc or torch burns	Partial melting of the cylinder, the addition of weld metal or the removal of metal by scarfing or cratering	All cylinders with such defects	Render unserviceable
Suspicious marks	Marks introduced other than by the cylinder manufacturing process and approved repair	All cylinders with such defects	Continued use possible after additional inspection
Vertical stability		Deviation from verticality which could present a risk during service (especially if fitted with foot-ring)	Repair if possible or render unserviceable

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

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

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

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C.3.2 Types of corrosion

The types of corrosion may in general be classified as in Table C.2.

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

Type of corrosion	Definition	Rejection limits in accordance with Clause 6 [a]	Repair or render unserviceable
General corrosion	Loss of wall thickness over an area of more than 20 % of either the interior or exterior total surface area of the cylinder (see Figure C.3)	If the original surface of the metal is no longer recognizable or if the depth of penetration exceeds 10 % of the original wall thickness or if the wall thickness is less than minimum guaranteed wall thickness [b]	Repair possible [c] Repair possible [c] Render unserviceable
Local corrosion	Loss of wall thickness over an area of less than 20 % of either the interior or exterior total surface area of the cylinder, except for the other types of local corrosion described below.	If the depth of penetration exceeds 20 % of the original thickness of the cylinder wall or if the wall thickness is less than minimum guaranteed wall thickness [b]	Repair possible [c] Render unserviceable
Chain pitting or line corrosion	Corrosion forming a narrow longitudinal or circumferential line or strip, or isolated craters or pits which are almost connected (see Figure C.4)	If a total length of corrosion in any direction exceeds the diameter of the cylinder and the depth exceeds 10 % of the original wall thickness or if the wall thickness is less than minimum guaranteed wall thickness [b]	Repair possible [c, d] Render unserviceable
Isolated pits	Corrosion forming isolated craters, without significant alignment (see Figure C.5.)	If the diameter of the pits is greater than 5 mm, refer to the “local corrosion” row If the diameter of the pits is less than 5 mm, the latter should be assessed as carefully as possible in order to check that the remaining thickness of the wall or base is adequate for the intended use of the cylinder	See “local corrosion” row Repair possible [d]
Crevice corrosion	Corrosion associated with taking place in, or immediately around, an aperture	If, after thorough cleaning, the depth of penetration exceeds 20 % of the original wall thickness	Repair possible [c]

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

[b] If corrosion has reached limits of depth or extent, the remaining wall thickness should be checked with an ultrasonic device. The wall thickness may be less than the minimum guaranteed wall thickness, e.g., small (depth and extent) isolated pits, where authorized by the relevant regulations taking into consideration the severity of the defect and safety factors.

[c] After repair, a cylinder shall follow requirements in Clauses 7, 8 and 9.

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

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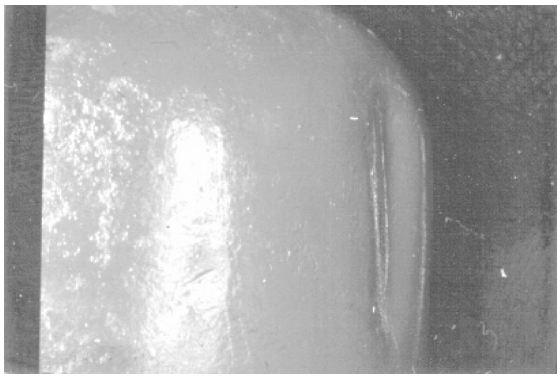

Figure C.1 — Cut or gouge

Figure C.2 — Crack

Figure C.3 — General corrosion

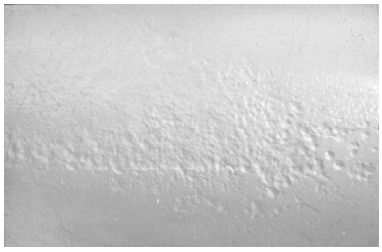

Figure C.4 — Line corrosion

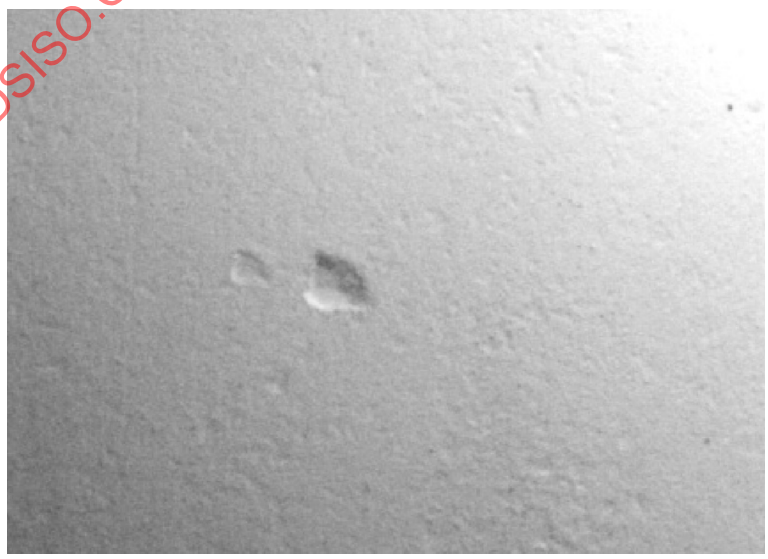

Figure C.5 — Isolated pits

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Annex D
(normative)

Procedure to be adopted when de-valving and/or when it is suspected that a cylinder valve is obstructed

D.1 Check for obstructed valve

The following procedures shall be carried out only by trained personnel. In view of the potential hazards in cylinders, this operation can lead to injury from stored energy release, fire and toxic hazards; hence, personnel shall take such precautions as deemed necessary for the work to be performed. When the gas, if any, has been released and the pressure within the cylinder reduced to atmospheric pressure, and, in the case of liquefied gases, when there is no frost or dew on the outside of the cylinder, the valve may be removed after an additional check is made to establish that there is free passage through the valve.

As indicated in Clause 6, a systematic check shall be made to establish that the passage through the valve is unobstructed. The method adopted shall be a recognized procedure such as one of the following or one that provides equivalent safeguards.

— Introduce a gas, non-reactive to the gas stored in the cylinder, at a pressure up to 5 bar and check its discharge.

— Use the device shown in Figure D.1 to hand pump air into the cylinder.

— 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 could contain either liquefied gas under pressure or contaminants. Lack of a positive difference does not rule out the presence of a gas under pressure.

D.2 Valve unobstructed

Only when it has been established that there is no obstruction to gas flow in the cylinder valve, may the valve be removed. Personal protection during de-valving shall be assessed.

D.3 Valve obstructed

The following methods are applicable for cylinders of non-toxic, non-flammable and non-chlorofluorocarbon (non-CFC) gases. Appropriate safety precautions should be taken to ensure that no hazard results from the uncontrolled discharge of any residual gas. When a cylinder is found to have an obstructed gas passage in the valve, the cylinder shall be set aside and handled by specially trained personnel in this task by one of the following methods.

— Saw or drill the valve body until interception is made with the gas passage between the valve body stem and valve spindle seat. The operation shall be properly cooled particularly when handling oxidizing gases.

— Loosen or pierce the pressure relief device in a controlled manner.

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