INTERNATIONAL STANDARD

ISO 6406

Second edition
2005-02-01

Gas cylinders — Seamless steel gas cylinders — Periodic inspection and testing

Bouteilles à gaz — Bouteilles à gaz en acier sans soudure — Contrôles et essais périodiques

Reference number
ISO 6406:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 6406 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 6406:1992), which has been technically revised.

Gas cylinders — Seamless steel gas cylinders — Periodic inspection and testing

1 Scope

This International Standard deals with seamless steel transportable gas cylinders (single or those that comprise a bundle) intended for compressed and liquefied gases under pressure, of water capacity from 0,5 l up to 150 l; it also applies, as far as practical, to cylinders of less than 0,5 l water capacity.

This International Standard specifies the requirements for periodic inspection and testing to verify the integrity of such gas cylinders to be re-introduced into service for a further period of time.

This International Standard does not apply to periodic inspection and testing of acetylene cylinders or composite cylinders with steel liners.

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 9712:—[1], *Non-destructive testing — Qualification and certification of personnel*

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

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

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

ISO 13769, *Gas cylinders — Stamp marking*

3 Intervals between periodic inspections and tests

A cylinder shall be due for periodic inspection and test on its first receipt of a filler following the expiry of the interval established 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 Annex A).

Provided the cylinder has been subjected to normal conditions of use and has not been subjected to abusive and abnormal conditions that would render 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.

1) To be published. (Revision of ISO 9712:1999)

It is the responsibility of the owner or user to submit the cylinder for 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.

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 inspection and tests (Clause 5);

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

c) external visual inspection (Clause 7);

d) check of internal condition (Clause 8);

e) supplementary tests (Clause 9);

f) inspection of cylinder neck (Clause 10);

g) pressure test or ultrasonic examination (Clause 11);

h) inspection of valve and other accessories (Clause 12);

i) replacement of cylinder parts (Clause 13);

j) cylinder repairs (Clause 14);

k) final operations (Clause 15);

l) rejection and rendering cylinder unserviceable (Clause 16).

It is recommended that the procedures a) to l) be performed in the sequence listed. In particular, the check of internal condition [d)] should be carried out before the pressure test or before the ultrasonic examination [g)].

Cylinders that fail an inspection or test shall be rejected (see Clause 16). Where a cylinder passes the above-listed procedures but the condition of the cylinder remains in doubt, additional tests shall be performed to confirm its suitability for continued service (see Clause 9) or the cylinder shall be rendered unserviceable.

Depending on the reason for rejection, some cylinders may be recovered (see Annex B).

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

Mechanical properties of steel cylinders may be affected by heat exposure. Therefore, the maximum temperature for any operation shall be limited in accordance with the manufacturer's recommendation.

5 Identification of cylinder and preparation for inspections and tests

Before any work is carried out, the relevant cylinder data and its contents and ownership shall be identified (e.g. from the labelling and stamping, see ISO 13769). Cylinders with incorrect or illegible markings or unknown gas contents shall be set aside for special handling.

If the contents are identified as hydrogen or other embrittling gas, 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. Cylinders in accordance with ISO 13769 are stamped “H”.

All other cylinders shall be withdrawn from hydrogen service and their suitability for their new, intended service checked (see ISO 11621).

6 Depressurization and de-valving procedures

6.1 General

Cylinders to be internally inspected or tested by a pressure test are required to be depressurized and de-valved. Cylinders not internally visually inspected and tested by ultrasonic examination do not require complete depressurization and de-valving unless the ultrasonic examination indicates there is an unacceptable flaw present and the inspector wishes to investigate further (see 11.4)

6.2 Cylinders requiring depressurization

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

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

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

Similarly, in the case of cylinders disassembled from bundles and not equipped with cylinder valves, the connecting “T”-junctions shall also be checked to determine whether the gas is able to pass freely from the cylinders using, for example, the device shown in Figure D.1.

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

6.3 Cylinders not requiring de-valving

Cylinders shall be depressurized to below 5 bar before ultrasonic examination. For cylinders under inspection by the ultrasonic method, see 11.4.

7 External visual inspection

7.1 Preparation for external visual inspection

When necessary, the cylinder shall be cleaned and have all loose coatings, corrosion products, tar, oil or other foreign matter removed from its external surface by a suitable method, e.g. by brushing, shot-blasting (under closely controlled conditions), water jet abrasive cleaning, chemical cleaning or other suitable methods. 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 B).

If fused nylon, polyethylene or a similar coating has been applied and the coating is seen to be damaged or it prevents 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 (see Table B.1);

c) corrosion (see Table B.2). Special attention shall be given to areas where water may be trapped. These include the entire base area, the junction between the body and the foot-ring and the junction between the body and the shroud;

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

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

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

For rejection criteria, see Annex B. Cylinders no longer suitable for future service shall be rendered unserviceable (see Clause 16).

8 Check of internal condition

Cylinders shall be inspected internally in order to complete periodic inspection and testing requirements. For cylinders under examination by the ultrasonic method in lieu of the pressure test and when reference notches as specified in 11.4.4.2.2 are used for calibration, the valve need not be removed. Otherwise, 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 B). If cleaning is required, the cylinder shall be re-inspected after the cleaning operation.

For cylinders of non-corrosive gases and $< 0{,}5$ l water capacity with an internal neck diameter < 9 mm, alternative methods may be substituted for the internal visual inspection.

These are:

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

— looking for contamination, e.g. rust from the water used after the hydraulic test. If rust contamination is observed in the hydraulic test fluid, the cylinder shall be rendered unserviceable.

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. Only when all doubts are eliminated may the cylinder be further processed (see Annex B).

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;

— free of other imperfections.

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

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 B).

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 that 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 16).

11 Pressure test or ultrasonic examination

11.1 General

Each cylinder shall be submitted for either a pressure test or an ultrasonic examination.

WARNING — Appropriate measures shall be taken to ensure safe operation and to contain any energy that may 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 liquid, normally water, as the test medium. The hydraulic pressure test may be a proof pressure test or a volumetric expansion test as appropriate to the design specification of the cylinder. The hydraulic proof pressure test may be replaced by a pneumatic proof pressure test. Having decided to use one particular type of test, its results shall be final. The test pressure shall be in accordance with the stamp markings on the cylinder.

Once a cylinder has failed one of the above-mentioned tests, none of the other test methods shall be applied to approve the cylinder.

11.2 Proof pressure test

11.2.1 General

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

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 evidence of any leakage. Adequate safety precautions shall be taken during the test.

11.2.2 Test equipment

11.2.2.1 All rigid pipework, flexible tubing, valves, fittings and components forming the pressure system of the test equipment shall be designed to withstand a pressure of at least 1,5 × the maximum test pressure of any cylinder that may be tested.

11.2.2.2 Pressure gauges shall be of 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 at least once a month. The master gauge shall be calibrated in accordance with national requirements. The pressure gauge shall be chosen so the test pressure is between approximately one-third and two-thirds of the value capable of being measured on the pressure gauge.

11.2.2.3 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.

11.2.2.4 All joints within the system shall be leak tight.

11.2.2.5 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 given in 11.2.3.3.

11.2.3 Test criteria

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

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

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

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

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

11.2.4 Acceptance criteria

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

There shall be an 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.

11.3 Hydraulic volumetric expansion test

Annex E proposes typical methods for carrying out this test and gives details for determining the volumetric expansion of seamless steel gas cylinders by the preferred water jacket method or the non-water jacket method. The test methods, equipment and procedure chosen shall be approved by the authorized body. The water jacket volumetric expansion test shall be carried out on equipment with a levelling burette, with a fixed burette, or with a weighing bowl. Care shall be taken that the entire external surface of the cylinder is wet without the presence of any bubbles.

The permanent volumetric expansion of the cylinder expressed as a percentage of the total expansion at test pressure shall not exceed the percentage given in the design specification after the cylinder has been held at test pressure for a minimum period of 30 s. If this figure for permanent expansion is exceeded, the cylinder shall be rendered unserviceable.

11.4 Ultrasonic examination

11.4.1 Background

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

11.4.2 Scope

The ultrasonic examination (UE) of seamless steel gas cylinders (water capacity $\geqslant$ 2 l) within the framework of periodic inspections may be carried out in lieu of the tests described in 11.2 and 11.3.

11.4.3 Requirements

11.4.3.1 General

The cylindrical part of the cylinder, the transition to the shoulder, the transition at the base and critical zones of the base shall be examined ultrasonically with the help of an automated examination device (e.g. Figure 1). When such an examination device is not able to do this outside the cylindrical section, a supplementary manual examination shall be performed (see Figure 2).

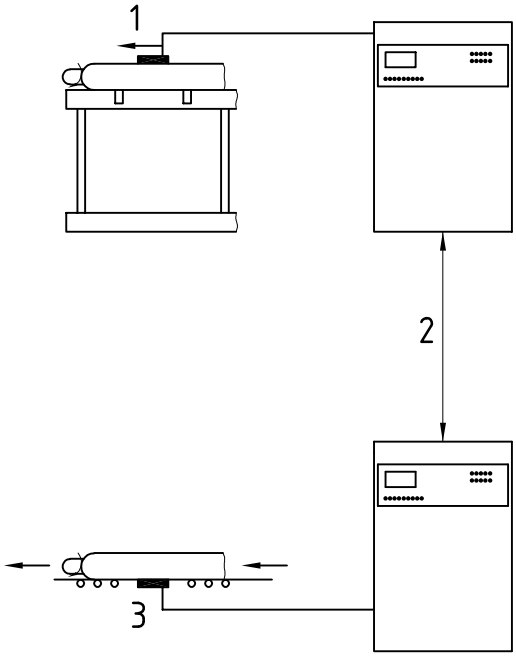
Cylinders that are suspected of fire or heat damage shall not be examined ultrasonically.

11.4.3.2 Examination equipment

The installation shall be able to scan the whole surface of the cylindrical part of the cylinder, including the adjacent transitions to the base and shoulder. An inspection system shall have a number and type of transducers and different beam directions required to identify all the reference features in the calibration piece. Such an installation may have five or more ultrasonic transducers suitably arranged (e.g. Figure 3).

Other arrangements of transducers may be possible provided that longitudinal and transverse defects can be detected.

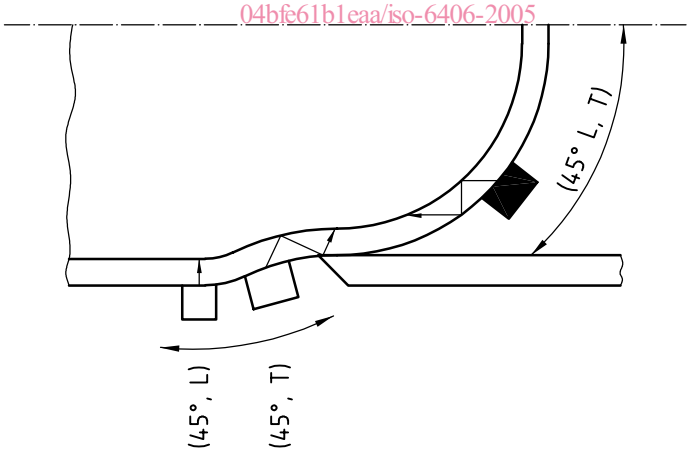
Any ultrasonic method (e.g. the pulse echo, guided wave) that demonstrates the ability to detect defects and to measure wall thickness shall be used. The most common techniques used today are the contact or the immersion type. Other techniques may be used. See Figure 4 as an example.



Key

1 UE transducers, moving
2 ultrasonic examination equipment
3 cylinder movement

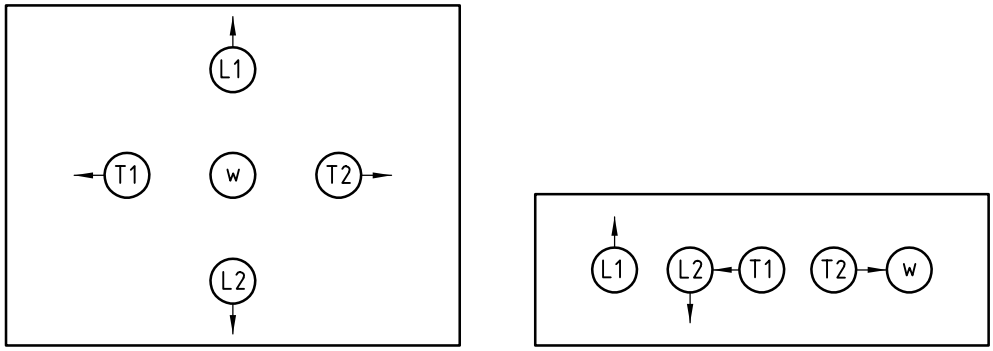
Figure 1 — Examples of two types of ultrasonic examination devices for gas cylinders



Key

L longitudinal of the base shape
T transverse of the base shape
■ manual (common practice)
☐ automated (common practice)

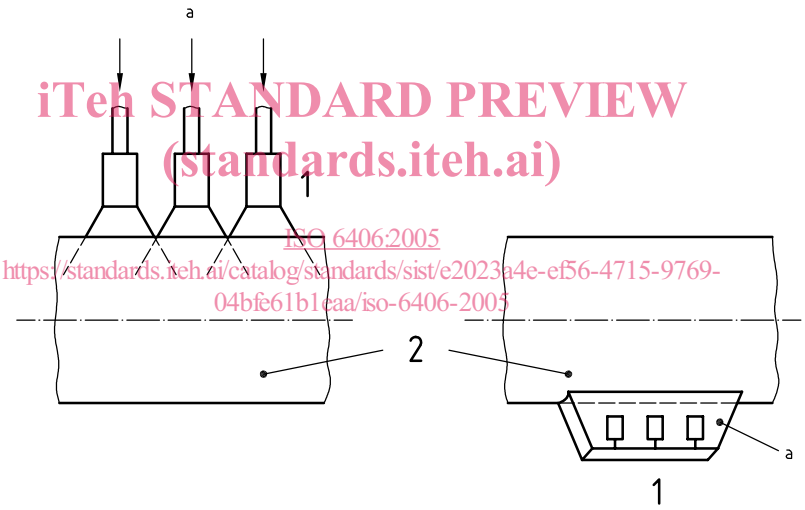
Figure 2 — Defect detection in cylinder ends with foot-rings



Key

L1, L2 longitudinal transducers
T1, T2 transverse transducers
w wall thickness transducer

Figure 3 — Examples of the arrangement of transducers



Key

1 transducers
2 cylinder

a Water.

Figure 4 — Examples of coupling techniques