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Gas cylinders — Seamless steel and aluminium-alloy gas cylinders — Evaluation of existing gas cylinders and consideration of their safe use in other jurisdictions

Bouteilles à gaz — Bouteilles à gaz en acier et en alliages d'aluminium, sans soudure — Évaluation des bouteilles à gaz existantes et considérations relatives à leur utilisation en toute sécurité dans d'autres jurisdictions

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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 voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

Introduction

In some circumstances, there may be a reason for seamless steel and seamless aluminium-alloy cylinders designed, approved and used to standards or specifications recognized in a given jurisdiction to be transferred for use in another jurisdiction (e.g. if a cylinder is no longer in service in the country of origin due to low service pressure).

In some jurisdictions, a procedure called reassessment of conformity exists such as that given in Directive 2010/35/EU on transportable pressure equipment (TPED) and Annex A of European standards such as EN 1968.

The objective of this document is to verify whether a cylinder manufactured in accordance with the specification of a given jurisdiction is acceptable for use in another country outside its original jurisdiction. This is accomplished through either verification of original manufacturing certification and information (when available) or through evaluation and testing of the cylinder in accordance with given criteria to determine that the cylinder is safe to be used in the new (receiving) jurisdiction.

Gas cylinders — Seamless steel and aluminium-alloy gas cylinders — Evaluation of existing gas cylinders and consideration of their safe use in other jurisdictions

1 Scope

This document details the checks, inspections and tests to be performed in order to qualify and certify existing seamless steel and aluminium-alloy cylinders of water capacity less than 150 l used for the transport of gases, manufactured in a jurisdiction in accordance with its national regulations, for use in jurisdictions other than that of manufacture or first use.

NOTE For specific requirements regarding gas cylinders that have been used in toxic gas service, see 5.7.

This document does not address acetylene cylinders.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6406, *Gas cylinders — Seamless steel gas cylinders — Periodic inspection and testing*

ISO 7866, *Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing*

ISO 9809-1, *Gas cylinders — Refillable seamless steel gas cylinders — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa*

ISO 9809-2, *Gas cylinders — Refillable seamless steel gas cylinders — Part 2: Quenched and tempered steel cylinders with tensile strength greater than or equal to 1 100 MPa*

ISO 9809-3, *Gas cylinders — Refillable seamless steel gas cylinders — Part 3: Normalized steel cylinders*

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

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

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

ISO 13769,[1)] *Gas cylinders — Stamp marking*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

1) To be published.

3.1
jurisdiction
country, region or group of countries or regions that have the same regulations for gas cylinders

3.2
manufacturing certificate
certificate of initial inspection and testing issued by an authorized body confirming that the cylinder complies with the applicable standards or specification at time of manufacture

3.3
owner
individual who, or organization that, owns the cylinder

3.4
group of cylinders
cylinders made of the same materials (steel or aluminium-alloy) defined by the production dates for a given period, during which the provisions of the applicable standards or specifications accepted by the competent authority have not changed in their technical content

3.5
batch
a number of cylinders from the same *group of cylinders* (3.4) that have similar characteristics such as same manufacturer, *working pressure* (3.6) and design standard

Note 1 to entry: For the purposes of this document, the term "batch" is not the same as a manufacturing batch.

3.6
working pressure
settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full gas cylinder

Note 1 to entry: In North America service pressure is often used to indicate a similar condition, usually at 21,1 °C (70 °F).

4 Symbols and abbreviated terms

a	calculated minimum thickness of the cylindrical shell wall, in mm
D	nominal outside diameter of the cylinder, in mm
P_h	hydraulic test pressure, in bars
R	0,75 x Rm-min, for normalized or normalized and tempered cylinders, or 0,85 x Rm-min, for quenched and tempered cylinders
Rm-min	minimum value of the tensile strength guaranteed by the cylinder manufacturer, in N/mm^2
Rm-max	maximum value of the tensile strength guaranteed by the cylinder manufacturer, in N/mm^2
HB-min	minimum Brinell hardness of the cylinder
HB-max	maximum Brinell hardness of the cylinder

NOTE If *Rm-min* is unknown, it should be calculated as shown in Annex B.

5 Requirements

5.1 Inspection body

The checks, inspections and tests outlined in this document shall be performed by an inspection body (hereafter referred to as "the inspector") authorized to do so by the competent authority in the jurisdiction in which the cylinder is intended to be used.

5.2 Information to be provided

5.2.1 General

The owner shall provide the inspector with all the information necessary to identify the cylinders, i.e. the groups of cylinders and number presented for qualification to the inspector.

5.2.2 Basic information

For each cylinder or batch of cylinders (as applicable), the following information shall be made available to the inspector for documentation, subsequent measurements/calculations and final evaluation:

a) name of manufacturer;

b) serial number;

c) identification of material of construction (e.g. AA6061, quenched and tempered chromium-molybdenum steel or normalized steel);

d) date of manufacture or initial test date;

e) regulation, standard or specification to which the cylinder was manufactured;

f) date and inspection mark of last periodic inspection and test station symbol, if applicable (from stamp marking or the periodic inspection and test certificate);

g) either test pressure and/or working pressure, as applicable;

h) external diameter;

i) necessary documentation to allow determination of acceptance for use by comparison with cylinders designed to a comparable ISO International Standard (see 6.1.1).

5.2.3 Additional information

For each cylinder or batch of cylinders, the inspector shall be provided further information from the owner either by documentation or by performing measurements/calculations as applicable:

a) minimum design wall thickness;

b) minimum yield strength and/or minimum tensile strength;

NOTE An indication of the tensile strength can be assessed by means of hardness tests (see 6.1.2).

c) nominal water capacity; and

d) valve to cylinder neck thread specification.

5.3 Verification of the information provided

The inspector shall verify that all necessary information is available to fully identify the cylinder and to allow verification as required in Clause 6.

5.4 Cylinders subject to restriction on use

The owner shall certify and the inspector shall check that the cylinders are not on any relevant notifications concerning restricted uses (e.g. national safety-related recall list, safety bulletins, alerts).

Additionally, if any restrictions of use apply, they shall continue to apply.

5.5 Compatibility with intended gas service

It is expected that the cylinder's gas service will remain the same. If not, the requirements of ISO 11621 shall be met when the cylinder undergoes a change of gas service.

The owner shall verify that the cylinders are compatible for the intended gas service, (i.e. that those cylinders for embrittling gas service or corrosive gas service conform to the requirements of ISO 11114-1).

5.6 Specific requirements for seamless steel cylinders used-in carbon monoxide service

The owner shall provide a written declaration to the inspector to verify that seamless steel cylinders are not in or have not been used in carbon monoxide or carbon monoxide mixture service.

Seamless steel cylinders that are known to have been used in carbon monoxide or carbon monoxide mixture service shall either not be used outside the jurisdiction of origin or their transfer is possible only if they continue to be used in carbon monoxide or carbon monoxide mixture service and follow ISO 11621:1997, 5.3.10.

5.7 Toxic gas service

The owner shall provide a written declaration to the inspector to verify that the cylinders have not been used in toxic gas service (other than carbon monoxide or carbon monoxide mixture service, see 5.6) during their last service. If this cannot be guaranteed, these cylinders shall not be transferred.

5.8 Manufacturing certificate or equivalent

The owner shall obtain the cylinders' original manufacturing certificates and provide them to the inspector. When manufacturing certificates are not available, the inspector shall follow the requirements of 6.1.2.

6 Acceptance by the inspector

6.1 General

6.1.1 Acceptance by documentary evidence

After all documents and/or information have been gathered and reviewed, the inspector shall determine that the information required in Clause 5 is available. The inspector shall verify that the cylinders comply with the relevant regulation, standard or specification to which the cylinders were manufactured.

In accordance with this document, the inspector shall determine that a cylinder is safe to be used in the new (receiving) jurisdiction if the cylinder meets the requirements of either 6.1.1 and 6.1.3 or 6.1.2 and 6.1.3.

The inspector shall also verify that the guaranteed minimum wall thickness/mechanical properties, the hydrogen compatibility and, for aluminium-alloy cylinders, the sustained load cracking (SLC) and stress corrosion cracking (SCC) requirements (as specified in the relevant regulation, standard

or specification of the jurisdiction of origin), are acceptable. ISO 9809-1, ISO 9809-2, ISO 9809-3 or ISO 7866, as applicable, may be used for guidance.

NOTE Some specifications are accepted in jurisdictions other than the original, e.g. cylinders manufactured to DOT specifications. In these cases, such cylinders can be used in these other jurisdictions (provided they are used under the same service conditions) without following the requirements of this document.

6.1.2 Alternative acceptance

If acceptance by documentary evidence in accordance with 6.1.1 cannot be confirmed, the cylinder may be qualified if the inspector is able to verify the following:

a) The inspector shall verify that the minimum wall and base thicknesses meet at least the minimum values as required by the relevant regulation, standard or specification to which the cylinder was manufactured or, if unknown, as calculated using the mean diameter formula (see Annex A).

   All cylinders shall be ultrasonically tested for defects and wall thickness in accordance with the method indicated in ISO 6406 or ISO 10461 as appropriate. This is to verify that the minimum wall and base thicknesses of each cylinder are equal to or greater than the minimum wall and base thickness prescribed by the relevant design specification and that the cylinders are free from harmful defects, as described in ISO 6406.

   Depending on the availability of documentary evidence for a given batch of cylinders, the inspector shall decide that these tests/measurements be performed either on all cylinders or randomly;

b) A hardness test shall be performed on each cylinder as described in ISO 9809-1 for seamless steel cylinders or in ISO 7866 for aluminium-alloy cylinders if information concerning mechanical properties is missing. The results shall meet the requirements in the original specification, if it required a hardness value. Any significant deviation outside normal distribution shall be indicated and explained on the cylinder's inspection report.

   Where the hardness value is not specified, a correlated hardness value shall be derived by performing tensile tests on cylinders that have been hardness tested and having the highest and the lowest hardness values. Annex B provides guidance for establishing this correlation. This method can also be used for aluminium-alloy cylinders.

   Depending on the availability of documentary evidence for a given batch of cylinders, the inspector shall decide that these tests/measurements be performed either on all cylinders or randomly;

c) For seamless steel cylinders intended for use in hydrogen or other embrittling gas service, in addition to 5.5, 6.1.2a) and 6.1.2b), pressure cycling tests as described in ISO 9809-1 shall be carried out for each batch of cylinders from the same manufacturer, same test pressure, same design specification and same nominal diameter. The acceptance criteria shall correspond to those described in ISO 9809-1. After completion of the pressure cycling test, the cylinders that have been used for testing shall be rendered unserviceable (see 6.2).

   For these types of cylinders, it is recommended that an ultrasonic inspection be performed on all cylinders in the batch;

d) Aluminium-alloy cylinders on which the SLC and SCC tests have not been performed (e.g. at time of type approval and with proper evidentiary proof) shall be tested and meet the requirements of ISO 7866; and

e) For seamless steel cylinders with tensile strength greater than 1100 MPa, additional tests shall be performed (e.g. Charpy or flawed burst tests). See ISO 9809-2 for guidance.

6.1.3 Periodic inspection requirements

At the time of acceptance under this document, a periodic inspection shall be performed on each cylinder in accordance with one of the following in this order of priority:

— the jurisdiction of origin;

— the receiving jurisdiction; or

— the applicable ISO International Standard for the type of cylinder (e.g. ISO 6406 or ISO 10461).

The cylinder shall not be used following the periodic inspection in accordance with this document and before its transfer date. During this period of time, the cylinder shall be protected from corrosion and all damage.

6.2 Final verification

After checking all documentation, test and inspection results, the inspector shall verify that the cylinders concerned met the requirements of either 6.1.1 and 6.1.3 or 6.1.2 and 6.1.3.

7 Marks

Cylinders passing the requirements of Clauses 5 and 6 shall be stamped with the periodic inspection marks (date and inspection stamp) immediately preceded by the mark "T" or a mark as determined by the competent authority and the mark of the inspector who authorized the "T" mark to confirm that the requirements of this document have been met.

If the marks are modified to avoid confusion during use in the new (receiving) jurisdiction, the revised marks should conform to ISO 13769[2)]. However, the sequence and format of the marks may be different.

8 Inspection report/certificate

The inspector shall prepare a report and submit it to the owner. The owner shall maintain records covering all cylinders assessed using this document.

As a minimum, the information required in Clause 5 and the results of the tests performed in Clause 6 shall be provided in this report.

2) To be published.

Annex A
(informative)

Calculating minimum wall and base thicknesses using the mean diameter formula

The minimum wall and base thicknesses, if the relevant regulation, standard, or specification is unknown, may be calculated.

Annex A provides an example of such calculation using the mean diameter formula (which is more conservative than the Lame von Mises formula).

The Lame von Mises formula may also be used (see ISO 9809-1 and 6.1.2a)) with the same principle.

The minimum wall thickness is at least equal to the greatest value given by the following:

1) $$a = \frac{\left(P_h \times D\right)}{\left(\frac{20R}{\left(4/3\right)} + P_h\right)}$$

2) $$a = \frac{D}{250} + 1 \text{ mm}$$

3) $a = 1{,}5$ mm

If a convex end is obtained by forging from tube, the wall thickness measured at the centre of the shaped end shall be at least $1{,}5a$.

The thickness of the concave base of cylinders shall not be less than $2a$ within the diameter on which the cylinder stands.

In order to ensure satisfactory stress distribution, the thickness of the cylinder walls shall increase progressively in the transition section between the cylindrical wall and the base.

Annex B
(informative)

Correlation between tensile strength and hardness

Correlated minimum and maximum values should be derived by performing tensile tests on cylinders that have been hardness tested and having highest and lowest values.

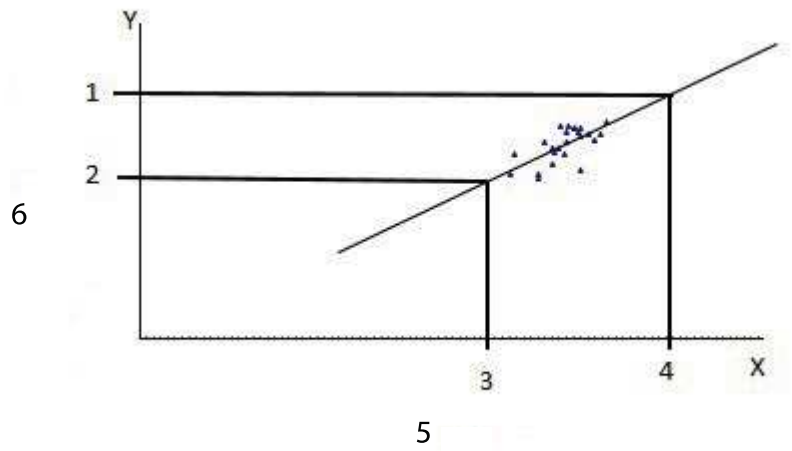
A minimum of 10 tensile coupons should be prepared from a minimum of three cylinders.

Coupons shall be randomly selected from top, bottom or the middle of the cylinders.

The hardness value should be recorded near the area of the tensile break on each of the 10 (or more) specimens.

A minimum hardness value shall be determined by the x-axis intersection of the correlating line and the guaranteed minimum tensile of the cylinder (see Figure B.1).

This method may also be used for aluminium-alloy cylinders.



Key

1 *Rm-max*
2 *Rm-min*
3 *HB-min*
4 *HB-max*
5 Brinell hardness (HB)
6 tensile strength

Figure B.1 — Determining a cylinder's minimum hardness value

Bibliography

[1] ISO 10286, *Gas cylinders — Terminology*

[2] ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*

[3] European Directive 2010/35/EU, *Directive on transportable pressure equipment*

[4] EN 1968, *Transportable gas cylinders — Periodic inspection and testing of seamless steel gas cylinders*

[5] EIGA Doc 86, *Gas cylinders and valves with restricted use in the EU*

[6] Title 49 of U.S. *Code of Federal Regulations* Part 173 (for restrictions on cylinders)

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