

Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement

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EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

<p>Käesolev Eesti standard EVS-EN ISO 11114-4:2005 sisaldab Euroopa standardi EN ISO 11114-4:2005 ingliskeelset teksti.</p> <p>Käesolev dokument on jõustatud 29.09.2005 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes.</p> <p>Standard on kättesaadav Eesti standardiorganisatsioonist.</p>	<p>This Estonian standard EVS-EN ISO 11114-4:2005 consists of the English text of the European standard EN ISO 11114-4:2005.</p> <p>This document is endorsed on 29.09.2005 with the notification being published in the official publication of the Estonian national standardisation organisation.</p> <p>The standard is available from Estonian standardisation organisation.</p>
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<p>Käsitlusala: This part of ISO 11114 specifies test methods and the evaluation of results from these tests in order to qualify steels suitable for use in the manufacture of gas cylinders (up to 3 000 l) for hydrogen and other embrittling gases.</p>	<p>Scope: This part of ISO 11114 specifies test methods and the evaluation of results from these tests in order to qualify steels suitable for use in the manufacture of gas cylinders (up to 3 000 l) for hydrogen and other embrittling gases.</p>
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ICS 23.020.30

Võtmesõnad:

ICS 23.020.30

English Version

Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement (ISO 11114-4:2005)

Bouteilles à gaz transportables - Compatibilité des matériaux des bouteilles et des robinets avec les contenus gazeux - Partie 4: Méthodes d'essai pour le choix de matériaux métalliques résistants à la fragilisation par l'hydrogène (ISO 11114-4:2005)

Ortsbewegliche Gasflaschen - Verträglichkeit von Werkstoffen für Gasflaschen und Ventile mit den in Berührung kommenden Gasen - Teil 4: Prüfverfahren zur Auswahl von metallischen Werkstoffen, die gegen Wasserstoffversprödung unempfindlich sind (ISO 11114-4:2005)

This European Standard was approved by CEN on 22 July 2005.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



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Foreword

This document (EN ISO 11114-4:2005) has been prepared by Technical Committee ISO/TC 58 "Gas cylinders" in collaboration with Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2006, and conflicting national standards shall be withdrawn at the latest by February 2006.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 11114-4:2005 has been approved by CEN as EN ISO 11114-4:2005 without any modifications, except as stated in normative annex NA.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

Annex NA
(normative)
Specific European requirements

With reference to the last paragraph of clause 4, the text of the last paragraph shall read as follows:

For the purposes of this European Standard, and for the qualification of a given steel for the manufacturing of gas cylinders, either method A), or method B) shall be used (see 5.1 and 5.2). Method C (see 5.3) shall not be used. Additionally, tensile tests shall be carried out (see 5.4).

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Annex ZA (normative)

Normative references to international publications with their relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE Where an International Publication has been modified by common modifications, indicated by (mod.), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN</u>	<u>Year</u>
ISO 7539-1	1987	<i>Corrosion of metals and alloys — Stress corrosion testing — Part 1: General guidance on testing procedures</i>	EN ISO 7539-1	1995
ISO 7539-6	2003	<i>Corrosion of metals and alloys – Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens.</i>	EN ISO 7539-6	2003
ISO 11114-1	1997	<i>Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials</i>	EN ISO 11114-1	1997
ISO 11120	1999	<i>Gas cylinders — Refillable seamless steel tubes for compressed gas transport, of water capacity between 150 l and 3 000 l — Design construction and testing</i>	EN ISO 11120	1999

**Transportable gas cylinders —
Compatibility of cylinder and valve
materials with gas contents —**

**Part 4:
Test methods for selecting metallic
materials resistant to hydrogen
embrittlement**

*Bouteilles à gaz transportables — Compatibilité des matériaux des
bouteilles et des robinets avec les contenus gazeux —*

*Partie 4: Méthodes d'essai pour le choix de matériaux métalliques
résistants à la fragilisation par l'hydrogène*



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Published in Switzerland

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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 11114-4 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*.

ISO 11114 consists of the following parts, under the general title *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents*:

- *Part 1: Metallic materials*
- *Part 2: Non-metallic materials*
- *Part 3: Autogenous ignition test in oxygen atmosphere*
- *Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement*

Introduction

It is widely recognised that compressed hydrogen and some hydrogen bearing gases can have an embrittling effect on metallic materials, especially steels. This embrittling effect has resulted in the failure of hydrogen cylinders (including some bursts) that has led gas cylinder users and manufacturers to adopt specific measures.

The adoption of these measures has eliminated all known failures of hydrogen cylinders from this embrittlement phenomenon.

The basic recommendation was to minimise the stresses in the cylinder wall (see ISO 11114-1) and eliminate harmful defects.

This tensile strength limit of 950 MPa was developed for quenched and tempered gas cylinders of 34 Cr Mo 4 type steels using steelmaking practices, chemistry and manufacturing techniques typical of those used during the early 1980s and successfully used for filling pressures up to 300 bar. This practice has been in widescale use up to the current time. Other higher pressures, although at lower tensile strength limits, have also been used.

In recent years, improvements in steelmaking, e.g. by reducing the sulphur and phosphorus contents, have indicated the possibility of increasing the tensile strength limit of 950 MPa for embrittling gas service, as a result of improvements in the fracture toughness of the material.

Experimental work has shown that the relevant parameters affecting hydrogen embrittlement are the following:

- a) microstructure resulting from the combination of the chemistry and the heat treatment;
- b) mechanical properties of the material;
- c) applied wall stress;
- d) internal surface imperfections resulting in local stress concentrations;
- e) characteristics of the gas contained (composition, quality, pressure, etc.).

When developing this part of ISO 11114 only the material aspects, a) and b) above, were considered. Other essential features, c) and d), are covered by the relevant parts of ISO 9809.

This part of ISO 11114 specifies test methods to identify steels which, when combined with the cylinder manufacturing requirements specified in ISO 9809 (all parts), will result in cylinders suitable for use in embrittling gas service.

However, some low alloy steels other than 34 Cr Mo 4 may require tensile strength lower than 950 MPa to be suitable for the manufacture of gas cylinders for embrittling gas service.

These tests have been developed following an extensive world-wide programme which incorporated laboratory and full scale tests.

Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents —

Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement

1 Scope

This part of ISO 11114 specifies test methods and the evaluation of results from these tests in order to qualify steels suitable for use in the manufacture of gas cylinders (up to 3 000 l) for hydrogen and other embrittling gases.

This part of ISO 11114 only applies to seamless steel gas cylinders.

The requirements of this part of ISO 11114 are not applicable if at least one of the following conditions for the intended gas service is fulfilled ¹⁾:

- the working pressure of the filled embrittling gas is less than 20 % of the test pressure of the cylinder;
- the partial pressure of the filled embrittling gas of a gas mixture is less than 5 MPa (50 bar) in the case of hydrogen and other embrittling gases, with the exception of hydrogen sulphide and methyl mercaptan in which cases the partial pressure shall not exceed 0,25 MPa (2,5 bar).

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 4287, *Geometrical product specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 7539-1:1987, *Corrosion of metals and alloys — Stress corrosion testing — Part 1: General guidance on testing procedures*

ISO 7539-6:2003, *Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens for tests under constant load or constant displacement*

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

1) In such cases the cylinders may be designed as for ordinary (non embrittling) gases.

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

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

ISO 11120, *Gas cylinders — Refillable seamless steel tubes for compressed gas transport, of water capacity between 150 l and 3 000 l — Design, construction and testing*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Some of the definitions used are based upon those in ISO 7539-1:1987.

3.1.1 embrittling gases

gases listed in ISO 11114-1:1997, Table A.3, group 2 and Table A.12, group 11

3.1.2 hydrogen rupture pressure, P_{H_2}

maximum pressure recorded during the hydrogen rupture pressure test

3.1.3 helium rupture pressure, P_{He}

maximum pressure recorded during the helium rupture pressure test

3.1.4 hydrogen embrittlement index

maximum value of the ratio P_{He}/P_{H_2} as a function of the pressure rise rate

3.1.5 environmentally-assisted cracking

synergistic effect on a metal caused by the simultaneous action of a particular environment and a nominally static tensile stress, which results in the formation of cracking

3.1.6 threshold stress

stress above which a crack will initiate and grow, for the specified test conditions

3.1.7 plane strain stress intensity factor, K_1

function of applied load, crack length and specimen geometry having dimensions of stress \times length

NOTE K_1 uniquely defines the elastic stress field intensification at the tip of a crack subjected to opening mode displacements.

3.1.8 threshold stress intensity factor for susceptibility to environmentally-assisted cracking, K_{1H}

stress intensity factor above which an environmentally-assisted crack will initiate and grow, for the specified test conditions under conditions of high constraint to plastic deformation, i.e. under essentially plane strain conditions

3.1.9 HAC

hydrogen assisted cracking