Irish Standard
I.S. EN ISO 11114-4:2017

Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting steels resistant to hydrogen embrittlement (ISO 11114-4:2017)

I.S. EN ISO 11114-4:2017

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National Foreword

I.S. EN ISO 11114-4:2017 is the adopted Irish version of the European Document EN ISO 11114-4:2017, Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting steels resistant to hydrogen embrittlement (ISO 11114-4:2017)

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 11114-4

April 2017

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Supersedes EN ISO 11114-4:2005

English Version

Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting steels resistant to hydrogen embrittlement (ISO 11114-4:2017)

Bouteilles à gaz transportables - Compatibilité des matériaux et des robinets avec les contenus gazeux - Partie 4: Méthodes d'essai pour le choix des aciers résistants à la fragilisation par l'hydrogène (ISO 11114-4:2017)

Ortsbewegliche Gasflaschen - Verträglichkeit von Werkstoffen für Gasflaschen und Ventile mit den in Berührung kommenden Gasen - Teil 4: Prüfverfahren zur Auswahl von Stählen, die gegen Wasserstoffversprödung unempfindlich sind (ISO 11114-4:2017)

This European Standard was approved by CEN on 8 December 2016.

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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 CEN-CENELEC Management Centre has the same status as the official versions.

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European foreword

This document (EN ISO 11114-4:2017) 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of an identical text or by endorsement, at the latest by October 2017, and conflicting national standards shall be withdrawn at the latest by October 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 11114-4:2005.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

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Endorsement notice

The text of ISO 11114-4:2017 has been approved by CEN as EN ISO 11114-4:2017 without any modification.

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INTERNATIONAL STANDARD

ISO 11114-4

Second edition
2017-04

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

Part 4: Test methods for selecting steels resistant to hydrogen embrittlement

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

Partie 4: Méthodes d'essai pour le choix des aciers résistants à la fragilisation par l'hydrogène

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

The committee responsible for this document is ISO/TC 58, *Gas cylinders*.

This second edition cancels and replaces the first edition (ISO 11114-4:2005), which has been technically revised with the following changes:

— improvement of the procedure corresponding to Method C and adjustment of acceptance criteria;

— light modifications on procedures corresponding to Method A and Method B.

A list of parts in the ISO 11114 series can be found on the ISO website.

Introduction

It is widely recognized that compressed hydrogen and some hydrogen bearing gases can have an embrittling effect on steels. This embrittling effect has resulted in the failure of hydrogen gas 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 as far has been reported.

The basic recommendation is to limit the tensile strength of the steels (see ISO 11114-1) and eliminate manufacturing 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 1980's 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. 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 stress;

d) internal surface imperfections resulting in local stress concentrations;

e) characteristics of the gas contained (composition, quality, pressure, etc.).

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

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

This document 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.

These tests have been developed following an extensive world-wide programme which incorporated laboratory and full scale tests. See also AFNOR FD E29-753.

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

Part 4: Test methods for selecting steels resistant to hydrogen embrittlement

1 Scope

This document 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 hydrogen bearing embrittling gases.

This document only applies to seamless steel gas cylinders.

The requirements of this document are not applicable if at least one of the following conditions for the intended gas service is fulfilled:

— 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 such cases, the partial pressure shall not exceed 0,25 MPa (2,5 bar).

NOTE In such cases, it is possible to design the cylinder as for ordinary (non-embrittling) gases.

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

ISO 7539-6:2011, *Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of precracked 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*

ISO 11114-1:2012, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11120, *Gas cylinders — Refillable seamless steel tubes of water capacity between 150 l and 3000 l — Design, construction and testing*

3 Terms, definitions, symbols and abbreviated terms

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 and ISO 7539-6.

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

3.1.1
embrittling gases
gases which can cause cracking of metal due to the combined action of stress and hydrogen atoms

Note 1 to entry: Embrittling gases are listed as groups 2 and 11 in ISO 11114-1:2012, A.4.

3.1.2
hydrogen rupture pressure
P_{H2}
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_{H2} 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 × $\sqrt{\text{length}}$ which uniquely define the elastic-stress field intensification at the tip of a crack subjected to opening mode displacements (mode I)

Note 1 to entry: 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