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Corrosion of metal and alloys — Determination of resistance of magnesium alloys to stress corrosion cracking

Corrosion des métaux et alliages — Détermination de la résistance des alliages de magnésium à la fissuration par corrosion sous contrainte

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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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Corrosion of metal and alloys — Determination of resistance of magnesium alloys to stress corrosion cracking

WARNING — This document calls for the use of substances and/or procedures that can be injurious to health if adequate safety measures are not taken. This document does not address any health hazards, safety or environmental matters associated with its use. It is the responsibility of the user of this document to establish appropriate health, safety and environmentally acceptable practices.

1 Scope

This document specifies a method for the determination of resistance to stress corrosion cracking (SCC) of magnesium alloys intended for use in structural applications (such as magnesium front end, gearbox and clutch housing units, steering column parts, shift actuators, valve covers and housings, brackets and intake manifold blades, electronic devices, power tools and medical equipment). The method allows determination of the resistance to SCC as a function of the chemical composition, the method of manufacture and heat treatment of magnesium alloys.

The document is applicable to cast and wrought magnesium alloys in the form of castings, semi-finished products, parts and weldments and covers the method of sampling, the types of specimens, the loading procedure, the type of environment and the interpretation of results.

The document allows assessment of the relative performance of materials and products in environments containing chlorides or sulphates, provided that the failure mechanism is not changed, but does not qualify a material or product for service application.

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 7539-4, *Corrosion of metals and alloys — Stress corrosion testing — Part 4: Preparation and use of uniaxially loaded tension specimens*

ISO 7539-7:2005, *Corrosion of metals and alloys — Stress corrosion testing — Part 7: Method for slow strain rate testing*

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044 and ISO 7539-1 apply.

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

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

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

4 General principles

4.1 Stress corrosion cracking of magnesium alloys is sensitive to microstructural orientation with respect to the stress axis. Accordingly, in testing SCC resistance, it is necessary to consider the manner in which the specimens are prepared from cast or wrought alloy so that orientation dependent SCC resistance can be assessed.

4.2 The corrosion of magnesium is associated with hydrogen evolution and generation of often very soluble corrosion products. For that reason, testing in stagnant conditions is preferred during continuous immersion as stirring can cause secondary effects, e.g. removal of corrosion product.

4.3 Two methods of immersion in the solution are proposed:

— alternate immersion;

— continuous immersion.

4.4 Tests may be conducted under constant load, constant strain or by the slow strain rate technique with evaluation criteria for stress corrosion cracking resistance appropriate to the chosen loading method.

4.5 The method of loading, the value of stresses, corrosive environment and criteria of evaluation should be agreed between the interested parties according to the purpose of the testing.

5 Apparatus and materials

5.1 Loading apparatus

Tensile stresses in the specimens are produced with yokes, stressing screws, springs, lever devices and special testing machines.

5.2 Construction materials for the test set-up

5.2.1 If in contact with the corrosive environment, the construction materials for the test set-up shall not be affected by the corrodent to such an extent that they can cause contamination of the solution and change its corrosiveness.

5.2.2 Use of inert plastics or glass is recommended for the corrosion cell where feasible.

5.2.3 Metallic components in contact with the solution shall be made from an appropriate corrosion resistant material, or protected with a suitable corrosion-resistant coating, sufficient to avoid galvanic coupling.

5.3 Specimen holders

5.3.1 The specimen holders shall be designed to electrically insulate the specimens from each other and from any bare metal parts. When this is not possible, as in the case of certain stressing bolts or jigs, the bare metal contacting the specimen shall be isolated from the corrodent by a suitable coating. Protective coatings shall be of a type that will not leach inhibiting or accelerating ions or protective oils or leave any residue, e.g. vapour, on the non-coated portions of the specimen holder. In particular, coatings containing chromates or releasing any other contaminants should be avoided. All samples holders should be degreased before and after coating.

5.3.2 The equipment required for slow strain rate testing is a device that permits a selection of strain rates while being powerful enough to cope with the loads generated. Strain rates that have been used most frequently in testing initially plain specimens are in the range 10^{-7} s^{-1} to 10^{-5} s^{-1}.

5.4 Apparatus for alternate immersion in solutions

5.4.1 Any suitable mechanism may be used to accomplish the immersion portion of the cycle provided that

a) it achieves the specified rate of immersion and removal, and

b) the apparatus is constructed of suitable inert materials.

The usual methods of alternate immersion are

a) specimens are placed on a movable rack that is periodically lowered into a stationary tank containing the solution,

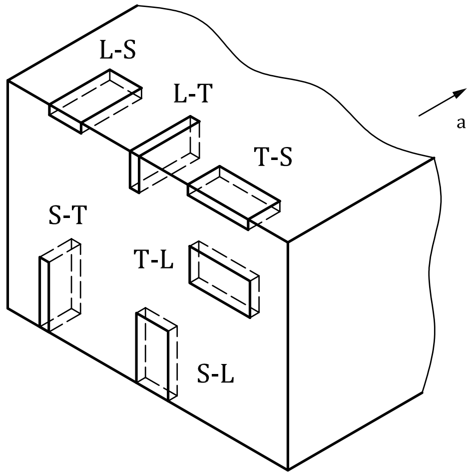
b) specimens are placed on a corrosion wheel arrangement which rotates every 10 min through 60° and thereby passes the specimens through a stationary tank of solution, and

c) specimens are placed in a stationary tray open to the atmosphere and the solution is moved by air pressure, by a non-metallic pump, or by gravity drain from the reservoir to the tray.

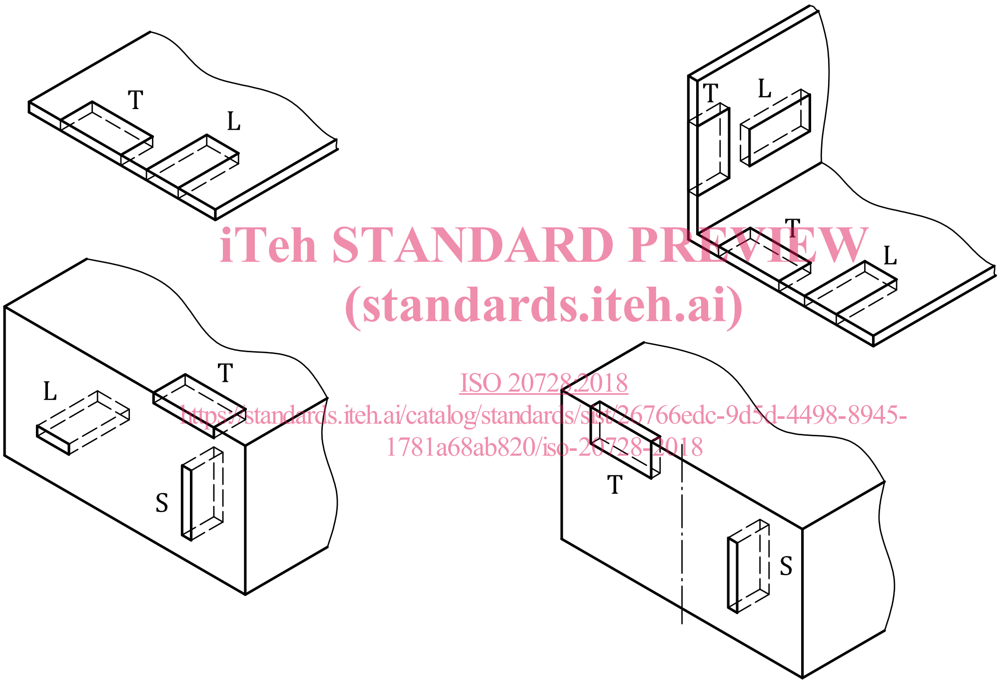
5.4.2 The rate of immersion and removal of the specimens from the solution shall be as rapid as possible without jarring them. For purposes of standardization, an arbitrary limit shall be adopted such that no more than 2 min elapses in the transfer from solution to air or vice versa.

6 Sampling

6.1 In general, this document specifies three specimen orientations for thick products and two for thin products. The orientation diagram is given in Figure 1. In Figure 1 a), the first direction refers to the stress axis and the second direction refers to the direction of crack growth.



a) General procedure



b) Recommended procedure

Key

Directions

L-T longitudinal-long transverse

L-S longitudinal-short transverse

T-L long transverse-longitudinal

T-S long transverse-short transverse

S-L short transverse-longitudinal

S-T short transverse-long transverse

L longitudinal direction

T long transverse direction

S short transverse direction

[a] Working direction.

Figure 1 — Specimen orientation

6.2 Unless otherwise specified, tests should be performed in the short transverse direction (S) for thick products and in the long transverse direction (T) for thin products.

For cast material, the preparation of samples from areas close to the casting surface should be avoided except in cases in which this area is intended to be studied. The local solidification rate while preparing the samples should be considered.

In rolled or extruded sections that are approximately round or square, the specimens should be oriented with the applied stress oriented in the transverse (diametrical) direction so that the crack path is in the rolling/extrusion direction. In any case, the sampling with respect to the orientation and/or to the rolling direction and/or by the texture should be reported.

In the case of forgings and, more generally, when the structure of the test pieces is not obvious, the grain direction should be determined by macro etching (see Annex A), or by metallographic examination, in order to select specimens in the most susceptible directions.

6.3 The number of specimens to be submitted to testing should be agreed between the interested parties. When testing at a single stress level only four or more specimens from the same location in the parent material shall be tested; or, if tests are being conducted at multiple stress levels three or more specimens per stress level are acceptable.

7 Specimens

7.1 Type and sizes

7.1.1 Specimens as defined by ISO 7539-2 to ISO 7539-6 can be used.

7.1.2 Tension specimens, C-ring specimens or bend specimens can be taken from thick products, for example from plates or forgings.

7.1.3 Tension specimens, bent beam specimens or U-bend specimens can be taken from thin products, for example from sheets.

7.1.4 Notched or pre-cracked specimens may be used when it is desired to measure threshold to cracking or crack growth rates. They may also be used to confine crack initiation and propagation to certain regions of the microstructure such as the heat affected zone of a weld. Notched or pre-cracked specimens may also be used to restrict load requirements, where bending, as opposed to tensile loading, can offer further advantages.

7.1.5 The comparison of different alloys and tempers should be conducted on specimens of the same type and size. Where possible, specimens should be heat treated before final machining, otherwise consideration must be given to the removal of oxidation products from the surface (see 7.2.4).

7.2 Surface preparation

7.2.1 The surface quality of a specimen shall comply with the following:

— without mechanical machining: in the as-supplied condition;

— with mechanical machining: the arithmetical mean deviation of the profile (R_a) should be less than or equal to 1 µm, with a preferred value of 0,25 µm or finer, unless it is required to simulate an as-manufactured surface condition;

— the surface condition of welded specimens should be agreed between the interested parties.