NSAI Standards

Irish Standard
I.S. EN ISO 7539-10:2020

Corrosion of metals and alloys - Stress corrosion testing - Part 10: Reverse U-bend method (ISO 7539-10:2020)

I.S. EN ISO 7539-10:2020

Incorporating amendments/corrigenda/National Annexes issued since publication:

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National Foreword

I.S. EN ISO 7539-10:2020 is the adopted Irish version of the European Document EN ISO 7539-10:2020, Corrosion of metals and alloys - Stress corrosion testing - Part 10: Reverse U-bend method (ISO 7539-10:2020)

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 7539-10

May 2020

ICS 77.060

Supersedes EN ISO 7539-10:2014

English Version

Corrosion of metals and alloys - Stress corrosion testing - Part 10: Reverse U-bend method (ISO 7539-10:2020)

Corrosion des métaux et alliages - Essais de corrosion sous contrainte - Partie 10: Méthode d'essai par cintrage en U inversé (ISO 7539-10:2020)

Korrosion der Metalle und Legierungen - Prüfung der Spannungsrisskorrosion - Teil 10: Vorbereitung und Anwendung von reversierten Bügelproben (ISO 7539-10:2020)

This European Standard was approved by CEN on 10 May 2020.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN ISO 7539-10:2020) has been prepared by Technical Committee ISO/TC 156 "Corrosion of metals and alloys" in collaboration with Technical Committee CEN/TC 262 “Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys” 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of an identical text or by endorsement, at the latest by November 2020, and conflicting national standards shall be withdrawn at the latest by November 2020.

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

This document supersedes EN ISO 7539-10:2014.

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Endorsement notice

The text of ISO 7539-10:2020 has been approved by CEN as EN ISO 7539-10:2020 without any modification.

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INTERNATIONAL STANDARD

ISO 7539-10

Second edition
2020-05

Corrosion of metals and alloys — Stress corrosion testing —

Part 10: **Reverse U-bend method**

Corrosion des métaux et alliages — Essais de corrosion sous contrainte —

Partie 10: Méthode d'essai par cintrage en U inversé

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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).

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

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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262 *Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 7539-10:2013), which has been technically revised. The main changes compared with the previous edition are as follows:

— the specimen preparation, i.e. how RUB specimens are machined, bent and fastened, has been revised in Clause 5 and Annexes A and B;

— the experimental procedure of how specimens are tested in a multiple immersion test with different periods or in a serial immersion test has been revised in Clause 6;

— the post-exposure evaluation of how specimens are observed has been revised in Clause 7;

— information has been added for the test report in Clause 8;

— Figures A.1, A.2 and B.3 and Table B.1 have been revised;

— new Figures A.3 and B.4 have been added to illustrate the RUB specimen before and after fastening.

A list of all parts in the ISO 7539 series can be found on the ISO website.

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 metals and alloys — Stress corrosion testing —

Part 10:
Reverse U-bend method

WARNING — This document can involve hazardous materials, operations and equipment. It is the responsibility of the user of this document to consult and establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

1 Scope

This document specifies procedures for designing, preparing and using reversed U-bend (RUB) test specimens for investigating the susceptibility of the metal to stress corrosion cracking. The term "metal" as used in this document includes alloys.

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 8407, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 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 Principle

The RUB test is a particularly severe test for assessing susceptibility to stress corrosion cracking. The test is intended primarily for application to metals with high corrosion resistance, such as Ni-based alloys, with the advantage, compared to methods such as the conventional U-bend test, of having significantly less stress relaxation. It is used primarily as a screening test for tubing, piping, plate, bar and other products including welded materials. It may also be used as an acceptance test for performance in service subject to agreement between the parties.

The principle of the test is to introduce very severe stresses in a high corrosion resistance metal, with minimum relaxation, in order to enhance the likelihood of inducing stress corrosion cracking.

The test involves exposing a piece of metal of a semi-circular section bent back on itself (i.e. reversed bent) into a U-shape to the corroding medium and holding it in a manner that ensures that there are initial tensile stresses in excess of the yield strength over a large proportion of the inner surface. The test is accelerated by the presence of complex bi-axial stresses that may or may not exist in service. In the act of forming specimens, varying amounts of cold work may be introduced, and this deformation can influence the stress corrosion cracking tendency as compared to that of the material in the original condition.

The test is normally performed in a laboratory by exposing the specimens to simulated service conditions.

A further objective of the test is to compare and evaluate the influence of different material parameters.

The principal advantages of the test are its simplicity and its ability to provide a rapid screening. If conventional U-bend or C-ring specimens are used for screening tests in a high temperature solution of 573 K or higher, marked stress relaxation occurs and a long testing time is needed for the evaluation. However, the stress relaxation in RUB specimens is smaller than that in conventional U-bend and C-ring specimens, due to the bi-axial stresses in RUB specimens. Therefore, screening tests can be done within a relatively short time through the use of RUB specimens.

A disadvantage is that the stress state is complicated and is difficult to quantify with accuracy. If an accurate stress state is desired, an alternative method should be used.

Wide variations in test results can be obtained for a given metal and environment even when testing nominally identical specimens and the replication of tests is frequently necessary.

If specimens are prepared from tubing of different dimensions or are subjected to different stressing procedures, test results can be even more variable.

5 Specimens

5.1 General

RUB specimens are prepared from pieces of production tubing, piping and other hollow cylindrical products cut into half longitudinally or from a plate, bar or other products formed into a semi-circular shape along the axial direction. The specimens should be cut by sawing or other such methods that do not affect the material properties. Then they should be shaped into their dimensions by machining. The side face of the specimens should be deburred and then finished by sequentially coarse-to-fine grinding using abrasive papers or cloths to a surface finish such as P600 (see ISO 3366 or ISO 21948) without increasing the temperature of the specimens.

Two-stage stressing consisting of bending and fastening with a loading bolt should be performed for RUB specimens. Elastic-stress relief should be avoided during fastening RUB specimens with a loading bolt.

5.2 Preparation of RUB specimens

5.2.1 Tubing and piping

A variety of tube dimensions and specimen sizes can be employed. The tube is cut to selected specimen lengths and then sectioned axially to produce specimens with a semi-circular section.

The tubing shall retain its original surface finish.

If heat treatment is added, final heat treatment shall be performed before the reverse U-bending process (and pre-straining, if this is adopted).

5.2.2 Other products

A variety of bar stock, plate and other forged or rolled material or welded material can be employed. These materials shall be machined into a plate after final heat treatment and pressed into a semi-circular shape between inner and outer formers. The surface of the specimens shall be finished by sequentially coarse-to-fine grinding using abrasive papers or cloths up to a surface finish such as P600 (see ISO 3366 or ISO 21948) without increasing the temperature of the specimens before the pressing process. Specimen preparation from a plate is shown in Annexes A and B.

When testing welds, consideration shall be given to the orientation of the weld relative to the longitudinal axis of the specimen and this shall be noted. Tests may be conducted on the weld metal itself or on sections containing the weld metal and heat-affected zone.

5.2.3 Reverse U-bending process

During bending, deformation of the half tube may be constrained by the forming jig to force it to maintain its semi-circular cross-section or its sides may be allowed to deform freely, in which case it can tend to flatten at the apex. Both methods may be used. The latter procedure results in lower stresses but has the advantage of avoiding cracking at the edges. The former type specimen is called the "half tube RUB specimen", and the latter type specimen is called the "RUB specimen with a gauge section".

When testing RUB specimens with a gauge section, pre-straining can be used to achieve the desired stress level. The stresses generated in the RUB specimens with a gauge section during reverse U-bending are lower without pre-straining because of reduced constraint.

Examples of the preparation of non-pre-strained half tube RUB specimens are shown in Annex A.

Examples of the preparation of non-pre-strained and pre-strained RUB specimens with a gauge section are shown in Annex B.

The apex of the pressing template has a concave curve where the curvature is suited to the external diameter of the half tube, while the rolls have a convex curve where the curvature is suited to the internal diameter of the half tube.

Only RUB specimens that do not crack at the apex when bent should be adopted.

5.3 Fastening RUB specimens with a loading bolt

When fastening specimens with a loading bolt after a bending operation, care shall be taken to ensure that the deflection due to the fastening operation is restored beyond that reached at the end of the bending operation. RUB specimens should be stressed using a vice bench as the final stage of the bending operation before fastening the specimen to align its legs by attaching them with nuts and bolts. The final distance between the specimen's legs at the loading bolt shall be approximately 1 mm less than the minimum distance during the bending operation. The final distance should be the same for all specimens in a given series. Loosening after loading should be avoided. To obtain consistency, a micrometer measuring device should be used.

The bolting material should have a similar or lower coefficient of thermal expansion to that of the specimen. Washers with a curved surface should be used to avoid non-uniform loading on the specimen during the screwing of the bolt. The washers help to keep the same contact point on the bolt-holes of a specimen. In addition, the use of double nuts to reduce the likelihood of loosening of the bolts is recommended.

Bolting material that avoids galvanic corrosion with RUB specimens and is resistant to corrosion in the environment should be selected. In a high-pH environment, the same material as RUB specimens can be adopted, but zirconia should not be adopted. In high-temperature water, the use of oxidized zircaloy washers for insulation is recommended.

6 Experimental procedure

If more than one metal is present in a system, electrical insulation of the specimen may be necessary to avoid galvanic corrosion, depending on the test environment. Where insulation is used, the insulating material shall not deform during the test. Ceramic insulating materials are suitable provided that they are compatible with the test conditions.