SIST

SLOVENSKI STANDARD
oSIST prEN ISO 7539-9:2020

01-oktober-2020

Korozija kovin in zlitin - Preskušanje napetostne korozije - 9. del: Priprava in uporaba preskušancev z umetno razpoko za preskuse pri naraščajoči obremenitvi ali naraščajoči deformaciji (ISO/DIS 7539-9:2020)

Corrosion of metals and alloys - Stress corrosion testing - Part 9: Preparation and use of pre-cracked specimens for tests under rising load or rising displacement (ISO/DIS 7539-9:2020)

Korrosion von Metallen und Legierungen - Prüfung der Spannungsrisskorrosion - Teil 9: Vorbereitung und Anwendung von angerissenen Proben für die Prüfung mit zunehmender Kraft oder zunehmender Verformung (ISO/DIS 7539 9:2020)

Corrosion des métaux et alliages - Essais de corrosion sous contrainte - Partie 9: Préparation et utilisation des éprouvettes préfissurées pour essais sous charge croissante ou sous déplacement croissant (ISO/DIS 7539-9:2020)

Ta slovenski standard je istoveten z: **prEN ISO 7539-9**

ICS:

77.060	Korozija kovin	Corrosion of metals

oSIST prEN ISO 7539-9:2020 **en,fr,de**

DRAFT INTERNATIONAL STANDARD
ISO/DIS 7539-9

ISO/TC **156** Secretariat: **SAC**

Voting begins on: **2020-07-28** Voting terminates on: **2020-10-20**

Corrosion of metals and alloys — Stress corrosion testing —

Part 9: **Preparation and use of pre-cracked specimens for tests under rising load or rising displacement**

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

Partie 9: Préparation et utilisation des éprouvettes préfissurées pour essais sous charge croissante ou sous déplacement croissant

ICS: 77.060

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 7539-9:2020(E)

Contents

Foreword

ISO (the International Organisation for Standardisation) 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 organisations, 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 standardisation.

International Standards are drafted in accordance with the rules given in the Directives, Part 3.

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.

International Standard ISO 7539-9 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys, in collaboration with GKSS (Germany).*

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

Corrosion of metals and alloys - Stress corrosion testing -

Part 9:

Preparation and use of pre-cracked specimens for tests under rising load or rising displacement

1 Scope

1.1 This part of ISO 7539 covers procedures for designing, preparing and using pre-cracked specimens for investigating the susceptibility of metal to stress corrosion cracking by means of tests conducted under rising load or rising displacement. Tests conducted under constant load or constant displacement are dealt with in ISO 7539-6.

The term "metal" as used in this part of ISO 7539 includes alloys.

1.2 Because of the need to confine plasticity at the crack tip, pre-cracked specimens are not suitable for the evaluation of thin products such as sheet or wire and are generally used for thicker products including plate, bar, and forgings. They can also be used for parts joined by welding.

1.3 Pre-cracked specimens may be stressed quantitatively with equipment for application of a monotonically increasing load or displacement at the loading points.

1.4 A particular advantage of pre-cracked specimens is that they allow data to be acquired from which critical defect sizes, above which stress corrosion cracking may occur, can be estimated for components of known geometry subjected to known stresses. They also enable rates of stress corrosion crack propagation to be determined.

1.5 A principal advantage of the test is that it takes account of the potential impact of dynamic straining on the threshold for stress corrosion cracking.

1.6 At sufficiently low loading rates, the K_{ISCC} determined by this method can be less than or equal to that obtained by constant load or displacemenet methods and can be determined more rapidly.

2 Normative references

The following referenced documents are indispensable for the application of this document.T 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: *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 7539-7: *Corrosion of metals and alloys - Stress corrosion testing—Part 7: Slow strain rate stress corrosion tests.*

ISO 7539-8: *Corrosion of metals and alloys - Stress corrosion testing—Part 8:*

Preparation and use of specimens to evaluate weldments.

ISO 11782-2: *Corrosion of metals and alloys - Corrosion fatigue testing – Crack propagation testing using precracked specimens*

ISO 12135: *Metallic materials -- Unified method of test for the determination of quasistatic fracture toughness*

ISO 15653: *Metallic materials — Method of test for the determination of quasistatic fracture toughness of welds*

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in ISO 7539-6 as well as the following apply.

3.1 rate of change of crack opening displacement at loading plane

$$\dot{V}_{LL}$$

deflection at the loading point access measured over a fixed period

3.2 stress intensity factor at crack initiation

$K_{I\text{-init}}$

stress intensity applied at the commencement of measurable crack growth

3.3

range of stress intensity factor

ΔK_f**, in fatigue**

algebraic difference between the maximum and minimum stress intensity factors in a cycle

3.4

displacement rate d*q*/d*t*

rate of increase of the deflection either measured at the loading point axis or away from the loading line

4 Principle

4.1 The use of pre-cracked specimens acknowledges the difficulty of ensuring that crack-like defects introduced during either manufacture or subsequent service are totally absent from structures. Furthermore, the presence of such defects can cause a susceptibility to stress corrosion cracking which in some materials (e.g. titanium) may not be evident from tests under constant load on smooth specimens. The principles of linear elastic fracture mechanics can be used to quantify the stress situation existing at the crack tip in a pre-cracked specimen or structure in terms of the plane strain-stress intensity.

4.2 The test involves subjecting a specimen in which a crack has been developed from a machined notch by fatigue to an increasing load or displacement during exposure to a chemically agressive environment. The objective is to quantify the conditions under which environmentally-assisted crack extension can occur in terms of the threshold stress intensity for stress corrosion cracking, K_{ISCC}, and the kinetics of crack propagation.

4.3 Tests may be conducted in tension or in bending. The most important characteristic of the test is the low loading/displacement rate which is applied.

4.4 Because of the dynamic straining which is associated with this method the data obtained may differ from those obtained for pre-cracked specimens with the same combination of environment and material when the specimens are subjected to static loading only.

4.5 The empirical data can be used for design or life prediction purposes in order to ensure either that the stresses within large structures are insufficient to promote the initiation of environmentally-assisted cracking at whatever pre-existing defects may be present or that the amount of crack growth which would occur within the design life or inspection periods can be tolerated without the risk of unstable failure.

4.6 Stress corrosion cracking is influenced by both mechanical and electrochemical driving forces. The latter can vary with crack depth, opening or shape because of variations in crack-tip chemistry and electrode potential and may not be uniquely described by the fracture mechanics stress intensity factor.

4.7 The mechanical driving force includes both applied and residual stresses. The possible influence of the latter should be considered in both laboratory testing and the application to more complex geometries. Gradients in residual stress in a specimen may result in non-uniform crack growth along the crack front.

4.8 K_{ISCC} is a function of the environment, which should simulate that in service, and of the conditions of loading.

5 Specimens

5.1 General

5.1.1 A wide range of standard specimen geometries of the type employed in fracture toughness tests may be used, those most commonly employed are described in ISO 7539-6. The particular type of specimen used will be dependent upon the form, the strength and the susceptibility to stress corrosion cracking of the material to be tested and also on the objective of the test.

5.1.2 A basic requirement is that the dimensions shall be sufficient to maintain predominantiy triaxial (plane strain) conditions in which plastic deformation is limited in the vicinity of the crack tip. Experience with fracture toughness testing has shown that for a valid K_{Ic} measurement, both the crack length, *a,* and the thickness, *B*, should be not less than

$$2{,}5 \cdot \left(\frac{K_{Ic}}{R_{p0,2}} \right)^2$$

and that, where possible, larger specimens where both *a* and *B* are at least

$$4 \cdot \left(\frac{K_{Ic}}{R_{p0,2}} \right)^2$$

should be used to ensure adequate constraint.

From the view of fracture mechanics, a minimum thickness from which an invariant value of K_{ISCC} is obtained cannot cuurently be specified. The presence of an aggressive environment during stress corrosion may reduce the extent of plasticity associated with fracture and hence the specimen dimensions needed to limit plastic deformation. However, in order to minimize the risk of inadequate constraint, it is recommended that similar criteria to those employed during fracture toughness testing should be employed regarding specimen dimensions, i.e. both *a* and *B* should be not less than

$$2{,}5 \cdot \left(\frac{K_I}{R_{p0,2}} \right)^2$$

and preferably should be not less than

$$4 \cdot \left(\frac{K_I}{R_{p0,2}} \right)^2$$

where K_I is the stress intensity to be applied during testing.

As a test for its validity, the threshold stress intensity value eventually determined shall be substituted for K_I in the first of these expressions.

5.1.3 If the specimens are to be used for the determination of K_{ISCC}, the initial specimen size should be based on an estimate of the K_{ISCC} of the material (in the first instance, it being better to over-estimate the K_{ISCC} value and therefore use a larger specimen than may eventually be found necessary). Where the service application involves the use of material of insufficient thickness to satisfy the conditions for validity, it is permissible to test specimens of similar thickness, provided that it is clearly stated that the threshold intensity value obtained, K_{QSCC}, is of relevance only to that specific application. Where it is required to determine stress corrosion crack growth behaviour as a function of stress intensity, the specimen size should be based on an estimate of the highest stress intensity at which crack growth rates are to be measured.

5.1.4 A wide choice of specimen geometries is available to suit the form of the test material, the experimental facilities available and the objectives of the test. Two basic types of specimen can be used

a) those intended for being loaded by means of a tensile force;

b) those intended for being loaded by means of a bending force.

This means that crack growth can be studied under either bend or tension loading conditions. The specimens can be used for either the determination of K_{ISCC} by the initiation of a stress corrosion crack from a pre-existing fatigue crack using a series of specimens and for measurements of crack growth rates. Since the specimens are loaded during exposure to the test environment the risk of unnecessary incubation periods is avoided.

5.1.5 Crack length measurements can be made readily with a number of continuous monitoring methods such as the electrical resistance technique (Appendix C).

5.1.6 Bend specimens can in principle be tested in relatively simple cantilever beam equipment but specimens subjected to tension loading require a tensile test machine.

5.2 Specimen design

5.2.1 The specimens can be subjected to either tension or bend loading. Depending on the design, tension loaded specimens can experience stresses at the crack tip which are predominantly tensile (as in remote tension types such as the centre-cracked plate) or contain a significant bend component (as in crack-line loaded types such as compact tension specimens). The presence of significant bending stress at the crack tip can adversely affect the crack path stability during stress corrosion testing and can facilitate crack branching in certain materials. Bend specimens can be loaded in 3-point, 4-point or cantilever bend fixtures.

5.2.2 The occurrence of crack-line bending with an associated tendency for crack growth out of plane can be curbed by the use of side grooves.

5.2.3 A number of specimen geometries have specific advantages which have caused them to be frequently used for rising load/displacement stress corrosion testing. These include

a) compact tension (CTS) specimens which minimize the material requirement;

b) cantilever, three-point, and four-point bend specimens which are easy to machine and inexpensive to test;

c) C-shaped specimens which can be machined from thick walled cylinders in order to study the radial propagation of longitudinally oriented cracks.

Details of standard specimen designs for several of these types of specimen are given in Figures 1 to 3. Further examples for other geomteries including three-point bend can be found in Reference 1.

5.2.4 If required, for example if fatigue crack initiation and/or propagation is difficult to control satisfactorily, a chevron notch configuration as shown in Figure 4 may be used. If required, its included angle may be increased from 90° to 120°.

5.2.5 Where it is necessary to measure crack opening displacements knife edges for the location of displacement gauges can be machined into the mouth of the notch, as shown in Figure 5a). Alternatively, separate knife edges can either be screwed or glued onto the specimen at opposite sides of the notch, as shown in Figure 3b) Details of a suitable tapered beam displacement gauge are given in Figure 3c).

5.3 Stress intensity factor considerations

5.3.1 It can be shown using elastic theory that the stress intensity, K_I, acting at the tip of a crack in specimens or structures of various geometries can be expressed by relationships of the form

$$K_I = Q \cdot \sigma \sqrt{a}$$

where

Q is the geometrical constant,

σ is the applied stress in MPa,

a is the crack length in metres.

5.3.2 The solutions for K_I for specimens of particular geometry and loading method can be established by means of finite element stress analysis, or by either experimental or theoretical determinations of specimen compliance.

5.3.3 K_I values can be calculated by means of a dimensionless stress intensity coefficient, *Y*, related to crack length expressed in terms of *a/W* through relationship of the form

$$K_I = \frac{YP}{B\sqrt{W}}$$

for compact tension and C-shaped specimens, where *W* is the width of the specimen in metres and P is the applied load.

5.3.4 Where it is necessary to use side-grooved specimens in order to curb crack branching tendencies, etc., shallow side grooves (usually 5 % of the specimen thickness on both sides) can be used. Either semi-circular or 60° V-grooves can be used, but it should be noted that even with semi-circular side grooves of up to 50 % of the specimen thickness it is not always possible to maintain the crack in the desired plane of extension. Where side grooves are employed, the effect of the reduced thickness, B_n, due to the grooves on the stress intensity can be taken into account by replacing *B* by $\sqrt{B \cdot B_n}$ in the above expression. However, the influence of side grooving on the stress intensity factor is far from established and correction factors should be treated with caution, particularly if deep side grooves are used.

5.3.5 Solutions for *Y* for specimens with geometries which are often used for stress corrosion testing are given in Figures 7 to 9. ISO 11782-2, ISO 13235 and Reference 1 provide information for other geometries.

5.4 Specimen preparation

Residual stresses can have an influence on stress corrosion cracking. The effect can be significant when test specimens are removed from material in which complete stress relief is impractical, such as weldments, as-quenched materials and complex forged or extruded shapes. Residual stresses superimposed on the applied stress can cause the localised crack-tip stress intensity factor to be different from that computed solely from externally applied loads. The presence of significant residual stress often manifests itself in the form of irregular crack growth, namely excessive crack front curvature or out-of-plane crack growth, Measurement of residual stress is desirable.

5.4.1 Specimens of the required orientation (see Figure 10) shall, where possible, be machined in the fully heat-treated condition. For specimens in material that cannot easily be completely machined in the fully heat-treated condition, the final heat treatment may be given prior to the notching and finishing operations provided that at least 0.5 mm per face is removed from the thickness at this finish machining stage. However, heat treatment may be carried out on fully machined specimens in cases in which heat treatment will not result in detrimental surface conditions, residual stress, quench cracking or distortion.

5.4.2 After machining, the specimens shall be fully degreased in order to ensure that no contamination of the crack tip occurs during subsequent fatigue pre-cracking or stress corrosion testing. In cases where it is necessary to attach electrodes to the specimen by soldering or brazing for crack monitoring by means of electrical resistance measurements, the specimens shall be fully degreased following this operation prior to pre-cracking in order to remove traces of remnant flux.

5.5 Specimen identification

Specimen identification marks may be stamped or scribed on either the face of the specimen bearing the notch or on the end faces parallel to the notch.

