SLOVENSKI STANDARD
SIST EN ISO 7539-1:1999

01-oktober-1999

Korozija kovin in zlitin – Ugotavljanje pokanja zaradi napetostne korozije - 1. del: Splošna navodila za postopke preskušanja (ISO 7539-1:1987)

Corrosion of metals and alloys - Stress corrosion testing - Part 1: General guidance on testing procedures (ISO 7539-1:1987)

Korrosion der Metalle und Legierungen - Prüfung der Spannungsrißkorrosion - Teil 1: Allgemeine Richtlinien für Prüfverfahren (ISO 7539-1:1987)

Corrosion des métaux et alliages - Essais de corrosion sous contrainte - Partie 1: Guide général des méthodes d'essai (ISO 7539-1:1987)

Ta slovenski standard je istoveten z: EN ISO 7539-1:1995

ICS:

77.060	Korozija kovin	Corrosion of metals

SIST EN ISO 7539-1:1999 en

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 7539-1

May 1995

ICS 77.060

Descriptors: metals, alloys, tests, corrosion tests, stress corrision tests

English version

Corrosion of metals and alloys - Stress corrosion testing - Part 1: General guidance on testing procedures (ISO 7539-1:1987)

Corrosion des métaux et alliages - Essais de corrosion sous contrainte - Partie 1: Guide général des méthodes d'essai (ISO 7539-1:1987)

Korrosion der Metalle und Legierungen - Prüfung der Spannungsrißkorrosion - Teil 1: Allgemeine Richtlinien für Prüfverfahren (ISO 7539-1:1987)

This European Standard was approved by CEN on 1995-04-08. 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.

The European Standards exist 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, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart,36 B-1050 Brussels

Ref. No. EN ISO 7539-1:1995 E

Foreword

This European Standard has been taken over by the Technical Committee CEN/TC 262 "Protection of metallic materials against corrosion" from the work of ISO/TC 156 "Corrosion of metals and alloys" of the International Organization for Standardization (ISO).

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 1995, and conflicting national standards shall be withdrawn at the latest by November 1995.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Endorsement notice

The text of the International Standard ISO 7539-1:1987 was approved by CEN as a European Standard without any modification.

INTERNATIONAL STANDARD

ISO 7539-1

First edition
1987-08-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Corrosion of metals and alloys — Stress corrosion testing —

Part 1 : General guidance on testing procedures

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

Partie 1 : Guide général des méthodes d'essai

Reference number
ISO 7539-1 : 1987 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7539-1 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Corrosion of metals and alloys — Stress corrosion testing —

Part 1 : General guidance on testing procedures

0 Introduction

This part of ISO 7539 gives general guidance on the selection, use and interpretation of the significance of various test procedures that have been developed for the assessment of the resistance of metals and alloys to stress corrosion. These test procedures are described in a series of additional parts as follows :

Part 2 : *Preparation and use of bent-beam specimens.*

Part 3 : *Preparation and use of U-bend specimens.*

Part 4 : *Preparation and use of uniaxially loaded tension specimens.*

Part 5 : *Preparation and use of C-ring specimens.*

Part 6 : *Preparation and use of pre-cracked specimens.*

Part 7 : *Slow strain rate testing.*

1 Scope and field of application

This part of ISO 7539 describes the general considerations which apply when designing and conducting tests to assess susceptibility of metals to stress corrosion.

NOTE — Particular methods of test are not treated in detail in this document. These are described in the additional parts of ISO 7539.

2 Definitions

2.1 stress corrosion : Synergistic attack on a metal caused by the simultaneous action of a corrosive environment and nominally static tensile stress which usually results in the formation of cracks. This process frequently results in a significant reduction of the load-bearing properties of metallic structures.

NOTE — See *stress corrosion cracking* (3.1).

2.2 threshold stress (for stress corrosion) : The stress above which stress corrosion cracks initiate and grow, for the specified test conditions.

2.3 threshold stress intensity factor (for stress corrosion) : The stress intensity factor above which stress corrosion cracks will initiate, under conditions of high constraint to plastic deformation, i.e. under plane strain predominant conditions.

2.4 test environment : Either a service environment, or an environment produced in the laboratory, to which the test specimen is exposed and which is maintained constant or varied in an agreed manner. In the case of stress corrosion the environment is often quite specific (see clause 6).

2.5 start of test : The time when the stress is applied or when the specimen is exposed to the test environment, whichever occurs later.

2.6 crack initiation time : The period from the start of a test to the time when a crack is detectable by the means employed.

2.7 time to failure : The period elapsing between the start of a test and the occurrence of failure, the criterion of failure being the first appearance of cracking or the total separation of the test piece, or some agreed intermediate condition.

2.8 slow strain rate test : A test involving controlled extension or bending of the test specimen at a strain rate usually in the region 10^{-3} to 10^{-7} s^{-1}. The strain is increased either continuously or in steps, but not cyclically.

2.9 average crack velocity : The maximum depth of crack(s) due to stress corrosion, divided by the test time.

2.10 orientation : The direction of applied tensile stress of a test specimen with respect to some specified direction in the product from which it was prepared, e.g. the rolling direction in the plate.

3 Background

3.1 From the definition of stress corrosion (2.1) it is apparent that stress corrosion cracking is a particular case of stress corrosion and in some circumstances attack may not result in the formation of cracks. Although it is generally agreed that cracking is the usual result, other manifestations such as intergranular corrosion or elongated fissures, which are enhanced by the presence of stress, have also to be recognized.

Whilst recognizing that these differences exist, for the purpose of this document, which is concerned with test methods, the terms "stress corrosion" and "stress corrosion cracking" can be regarded as being synonymous as is usually the case in corrosion literature.

As far as this International Standard is concerned, all phenonema involving metal dissolution or the action of hydrogen introduced into the metal as the result of simultaneous effects of a corrosive environment and a tensile stress are included except for embrittlement by liquid metal and exfoliation corrosion.

NOTE — A distinction should be made between local dissolution due to deteriorations and those phenomena caused by hydrogen. The two types of phenomena may be superimposed but cannot be confused with a phenomenon directly imputable to deliberate hydrogen loading.

3.2 There exists a wide diversity of methods used for assessing the stress corrosion properties of metals. Each has its own particular advantage in certain situations.

3.3 It is important to realize that the word "test" has a special meaning in the context of stress corrosion resistance or susceptibility. Whether or not a stress corrosion process occurs in a given case depends on both the exposure conditions **and** the properties of the material. The word "susceptibility" to stress corrosion does not describe a material property or quality that can be located on a universally applicable scale, since the order of merit of a given set of alloys may vary with exposure conditions.

3.4 Ideally, in order to establish the risk of stress corrosion in a given application, it is necessary to carry out simulation testing under all likely service exposure conditions. In practice this is difficult, if not impossible, and rarely achieved, but a number of "standard tests" have been found as a result of experience to provide reasonable guidance on likely service behaviour for given specific applications. However, these laboratory "standard tests" are only appropriate to service conditions where experience has shown an appropriate relationship, however empirical, to exist. The fact that a given alloy passes or does not pass a test previously found useful in relation to another alloy may or may not be significant and a test that discriminates correctly between alloys used for a given application will not necessarily provide safe guidance if the exposure conditions are different. The use of a standard test beyond the point for which there is experience therefore requires validation.

3.5 In the following clauses attention is drawn particularly to the fact that the stress corrosion process can be extremely sensitive to small changes in exposure or test conditions. The user of materials is responsible for selecting the conditions under which stress corrosion tests are performed and the fact that some tests are described in this International Standard does not imply that these tests are the most appropriate ones for any given situation. The justification for describing these tests in a standard is that they are in widespread use and have been proven as valid for specific or common equipment-environment systems. However, the responsibility for interpretation of the test results remains with the user of materials and it is in no way diminished by the existence of this standard.

3.6 In addition to specific parts of this International Standard to cover the most widely used methods, it is considered that this more general document, concerned with the selection of test details and the interpretation of results, is required. In preparing this part, use has been made of an earlier review of the subject, updated where appropriate.

4 Selection of test method

4.1 Before embarking on a programme of stress corrosion testing, a decision has to be made regarding which type of test is appropriate. Such a decision depends largely upon the purpose of the test and the information required. Whilst some tests attempt to reproduce service conditions as closely as possible and are of value to the plant engineer, others may be designed to study a mechanistic aspect of failure. In the former, for example restrictions of material, space, time, etc., may mean the use of a relatively simple test procedure whereas in other circumstances more sophisticated testing techniques may be essential. Thus, studies of crack propagation rates may involve the use of pre-cracked specimens, although these may be inappropriate when considering, for example, the effects of surface finish. Although a number of sophisticated techniques are available, the adoption of a simple test may prove of great value in some circumstances when more elaborate techniques cannot be used.

4.2 When selecting a test method of the pass/fail type, it is important to realize that this should not be so severe that it leads to the condemnation of a material that would prove adequate for a particular service condition, nor should it be so trifling as to encourage the use of a material in circumstances where rapid failure would ensue.

4.3 The aim of stress corrosion testing is usually to provide information more quickly than can be obtained from service experience, but at the same time predictive of service behaviour. Among the most common approaches employed to achieve this are the use of higher stress, slow continuous straining, pre-cracked specimens, higher concentration of species in test environment than in service environment, increased temperature, and electrochemical stimulation. It is important however, that these methods be controlled in such a way that the details of the failure mechanism are not changed.

4.4 If it is too difficult to reproduce the service conditions exactly, it may be useful to analyse the stress corrosion process in order to determine as far as possible the main factors operating at different stages. The stress corrosion test then selected may involve only one step of the corrosion mechanism.

5 Stressing systems

5.1 General

Methods of loading test pieces, whether initially plain, notched or pre-cracked, can be conveniently grouped according to whether they involve

a) a constant total strain (see 5.2);

b) a constant load (see 5.3);

c) an applied slow strain rate (see 5.4).

In the case of pre-cracked specimens, threshold conditions are defined in terms of a stress intensity value K_{Iscc} and tests may also be conducted under constant strain intensity conditions.

Knowledge of the limitations of the various methods is at least as important as the choice of method of stressing.

5.2 Constant total strain tests

5.2.1 These form by far the most popular type of test as a group, since bend tests in a variety of forms come into this category. Furthermore, they simulate the fabrication stresses that are frequently associated with service failures.

5.2.2 Material in sheet form is frequently tested by bending; plate material is tested under tension or as C-rings, with the latter also used for testing tubular products and other semi-finished products of round cross-section.

5.2.3 Bend tests have the attraction of employing simple, and therefore frequently cheap, specimens and restraining jigs. The problems with such test methods are usually related to poor reproducibility of the stress level, if indeed any quantitative measure of this is available. Attemps to improve upon this situation have led to more sophisticated types of bend test, e.g. involving four-instead of three-point loading, but the limitations of simple bending theory, usually used to calculate the stress level, can lead to errors in anticipated stress especially when strains beyond the elastic limit are required. The use of strain gauges for measuring surface stresses may be useful in some circumstances. The fabrication of strip specimens to produce "U" bends introduces significant amounts of plastic deformation which may influence cracking response.

5.2.4 Tubular material may be tested in the form of C-rings or O-rings, the former being stressed by partial opening or closing of the gap and the latter by forced insertion of a plug that is appropriately oversized for the bore. The C-ring has also been found to be particularly useful for testing thick product forms, e.g. aluminium alloys in the short transverse direction.

5.2.5 Constant total strain tensile tests are sometimes preferred to bend tests, thus simplifying both the application and calculation of the stress. However, the former require more massive restraining frames than bend test specimens of similar cross-section.

5.2.6 The use of restraining frames may be avoided by employing internally stressed specimens containing residual stresses as the result of inhomogeneous deformation. The latter may be introduced by plastic bending, e.g. by producing a bulge in sheet or plate material, or by welding, but such tests involve problems in systematic variation of the initial stress, which usually achieves maximum values in the region of the yield stress. Moreover, elastic spring-back, in introducing residual stresses by bulging plate or partially flattening tube, may cause problems and where welding is involved the structural modifications may raise difficulties, unless the test is simulative of a practical situation.

5.2.7 Constant total strain specimens are sometimes loaded by being placed initially into conventional testing machines or similar devices and then, whilst being maintained in their strained condition, having a restraining frame attached. When the load applied by the testing machine is removed, the specimen remains stressed by virtue of the restraint imposed by the frame, the assumption being made that the strain in the specimen remains constant as the restraint is transferred from the testing machine to the frame. This implies a similar stiffness in the testing machine and frame, which is likely to be so only if the frame is relatively massive compared with the specimens.

5.2.8 The stiffness of the stressing frame employed, may also influence the time to failure of a specimen, quite apart from any effect that it may have upon the initial stress level. Thus, in most constant total strain tests and especially those upon ductile materials, the initial elastic strain in the specimen is converted in part to plastic strain as the crack propagates.

5.2.9 Once load relaxation has been initiated, the extent to which it proceeds can vary from specimen to specimen and this may influence time to failure according to the number of cracks or pits that develop. Marked load relaxation can be observed on a specimen with many cracks or pits whereas little load relaxation is observed when only a few cracks are present. If only one crack develops, it will not need to grow to large dimensions before sudden, final failure occurs because the applied load remains high, whereas the marked load relaxation associated with the presence of many stress corrosion cracks means that they must propagate much further before one of them becomes large enough to create the stress conditions, at a relatively small load, for sudden failure.

5.2.10 The extent to which the number of cracks present influences the test results naturally depends upon the stress corrosion system being studied, i.e. upon such properties as the fracture toughness of the material and even upon the aggressiveness of the environment employed. The result also depends upon the stiffness of the restraining jig employed. Thus the stiffer the frame the less the elastic strain that is likely to remain in the specimen after the propagation of a Luders