BS EN ISO 7539-1:2012

BSI Standards Publication

Corrosion of metals and alloys — Stress corrosion testing

Part 1: General guidance on testing procedures

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National foreword

This British Standard is the UK implementation of EN ISO 7539-1:2012. It supersedes BS EN ISO 7539-1:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/NFE/8, Corrosion of metals and alloys.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN ISO 7539-1:2012) 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” 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of an identical text or by endorsement, at the latest by June 2013, and conflicting national standards shall be withdrawn at the latest by June 2013.

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.

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Endorsement notice

The text of ISO 7539-1:2012 has been approved by CEN as a EN ISO 7539-1:2012 without any modification.

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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

This second edition cancels and replaces the first edition (ISO 7539-1:1987), which has been technically revised.

ISO 7539 consists of the following parts, under the general title *Corrosion of metals and alloys — Stress corrosion testing*:

— *Part 1: General guidance on testing procedures*

— *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 for tests under constant load or constant displacement*

— *Part 7: Method for slow strain rate testing*

— *Part 8: Preparation and use of specimens to evaluate weldments*

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

— *Part 10: Reverse U-bend method*

— *Part 11: Guidelines for testing the resistance of metals and alloys to hydrogen embrittlement and hydrogen-assisted cracking*

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INTERNATIONAL STANDARD ISO 7539-1:2012(E)

Corrosion of metals and alloys — Stress corrosion testing —

Part 1: General guidance on testing procedures

1 Scope

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

1.2 This part of ISO 7539 also gives some general guidance on the selection of test methods.

NOTE 1 Particular methods of test are not treated in detail in this part of ISO 7539. These are described in the additional parts of ISO 7539.

NOTE 2 This part of ISO 7539 is applicable to cathodic protection conditions.

2 Terms and definitions

2.1
stress corrosion
process involving conjoint corrosion and straining of the metal due to applied or residual stress

2.2
threshold stress
⟨stress corrosion⟩ stress above which stress corrosion cracks initiate and grow, for the specified test conditions

2.3
threshold stress intensity factor
K_{ISCC}
⟨stress corrosion cracking⟩ stress intensity factor above which stress corrosion crack propagation is sustained

Note 1 to entry: The threshold stress intensity factor is a concept of linear elastic fracture mechanics (LEFM) and is applicable when the plastic zone size is large compared with the microstructure and a high constraint to plastic deformation prevails; i.e. under plain strain-predominant conditions. For growing stress corrosion cracks, LEFM is not necessarily applicable in detail but is adopted as a pragmatic tool that is commonly used.

Note 2 to entry: Stress corrosion cracks may initiate at a surface or a surface defect and grow in the "short crack" regime at stress levels below the apparent threshold stress intensity factor. However, LEFM is not applicable in the short crack regime and sustained propagation of these cracks requires that the threshold stress intensity factor be exceeded.

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

Note 1 to entry: In the case of stress corrosion, the environment is often quite specific (see Clause 6).

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

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

2.7
time to failure
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
test for evaluating the susceptibility of a metal to stress corrosion cracking that most commonly involves pulling a tensile specimen to failure in a representative environment at a constant displacement rate, the displacement rate being chosen to generate nominal strain rates usually in the range 10^{-5} s^{-1} to 10^{-8} s^{-1}

Note 1 to entry: Slow strain rate testing may also be applied to specimens in bend.

2.9
strain to failure
strain at which failure occurs in a slow strain rate test expressed usually as the plastic strain to failure See ISO 7539-7.

2.10
average crack velocity
maximum depth of crack(s) due to stress corrosion, divided by the test time

2.11
orientation
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 Although it is generally agreed that cracking is the usual result of stress corrosion, other manifestations such as intergranular corrosion or elongated fissures, which are enhanced by the presence of stress, have also to be recognized.

As far as this part of ISO 7539 is concerned, all phenomena 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.

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 Stress corrosion cracking depends on both the exposure conditions and the mechanical and microstructural characteristics of the material and susceptibility or resistance to stress corrosion can only be defined in that context. Thus, for example, there is no intrinsic threshold stress intensity factor for a material.

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

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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 part of ISO 7539 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 ISO 7539 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.

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. While 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.

4.5 A brief guide to the selection of test methods is included in Annex A.

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