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Corrosion of metals and alloys — Stress corrosion testing —

Part 3:
Preparation and use of U-bend specimens

Corrosion des métaux et alliages — Essais de corrosion sous contrainte —
Partie 3: Préparation et utilisation des éprouvettes cintrées en U

Reference number
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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.

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 7539-3 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys.*

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*
- *Part 7: Slow strain rate testing*
- *Part 8: Preparation and use of welded specimens*

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
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Introduction

This part of ISO 7539 is one of a series giving procedures for designing, preparing and using various forms of test specimen to carry out tests to establish a metals resistance to stress corrosion.

Each of the standards in the series needs to be read in association with ISO 7539-1. This helps in the choice of an appropriate test procedure to suit particular circumstances as well as giving guidance towards assessing the significance of the results of the tests.

Corrosion of metals and alloys — Stress corrosion testing —

Part 3:
Preparation and use of U-bend specimens

WARNING — U-bend specimens made from high strength materials may fracture rapidly; pieces may fly off at high velocity and can be dangerous. Personnel installing and examining specimens must be made aware of this possiblity and be protected against injury.

1 Scope

1.1 This part of ISO 7539 covers procedures for designing, preparing and using U-bend test specimens for investigating the susceptibility of a metal to stress corrosion.

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

1.2 U-bend specimens may be used to test a variety of product forms. They are used principally for sheet, plate or flat extruded material, which conveniently provides flat specimens of rectangular cross-section, but may also be employed for wire or rod, or for machined specimens of circular cross-section. They can also be used for parts joined by welding.

1.3 The U-bend test is frequently used to establish whether a metal is susceptible to stress corrosion cracking in a given environment. It is used in laboratories to screen materials for susceptibility for specific applications and in service environments to assess the risk of failure.

1.4 The principal advantages of the test are its simplicity and its consequent adaptability for use in plant. A disadvantage is that stresses cannot be quantified with accuracy and if this is desired an alternative method of stressing should be used.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 7539. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7539 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7539-1 : 1987, *Corrosion of metal and alloys — Stress corrosion testing — Part 1: General guidance on testing procedures.*

3 Definitions

For the purposes of this part of ISO 7539, the definitions given in ISO 7539-1 are applicable.

4 Principle

4.1 The test consists in exposing to the corroding medium a piece of metal bent into a U-shape and held in a manner which ensures that there are initial tensile stresses ranging up to the yield point over a proportion of the surface. In the act of forming specimens, varying amounts of cold work may be introduced and this deformation may influence the stress corrosion cracking tendency as compared to that of the material in the original condition.

4.2 The test may be performed under laboratory conditions by exposing the specimens to simulated service conditions or it may be carried out in the actual service environment at the location of interest.

4.3 The objective of the test is either to establish whether a metal is suitable for a proposed application or to assess the risk of stress corrosion cracking of metals used in existing plant under service conditions.

4.4 Wide variations in test results may 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 to different sizes or orientations or are subjected to different stressing procedures, test results may be even more variable.

5 Specimens

5.1 A variety of specimen shapes and sizes can be employed and figure 1 shows examples of specimens often used. Figure 2 indicates some methods of forming the specimens. To simulate crevice conditions, it is possible to form a second specimen over the first, thereby creating a crevice between the two, and to test the composite specimen [see figure 1 d)].

5.2 When stressing specimens by fastening after forming, care should be taken to ensure that the deflection is restored to that obtained at the end of the forming operation.

5.3 Specimens for use in service conditions should be securely fixed to avoid movement through the system and should be accessible for inspection or removal. Their design and method of fixing should be considered as a whole.

5.4 If more than one metal is present in a system, specimens should be electrically insulated to avoid galvanic effects.

5.5 Specimens should be fabricated from representative material with due regard to such factors as rolling direction and heat treatment.

If relevant, welded specimens should be tested, and the configuration in service should be borne in mind when preparing the specimens.

5.6 For laboratory testing a fine surface finish is frequently used since it allows early detection of cracks, but for in-service testing a surface finish representative of the plant should be employed. For further comments relating to surface condition, ISO 7539-1 should be consulted.

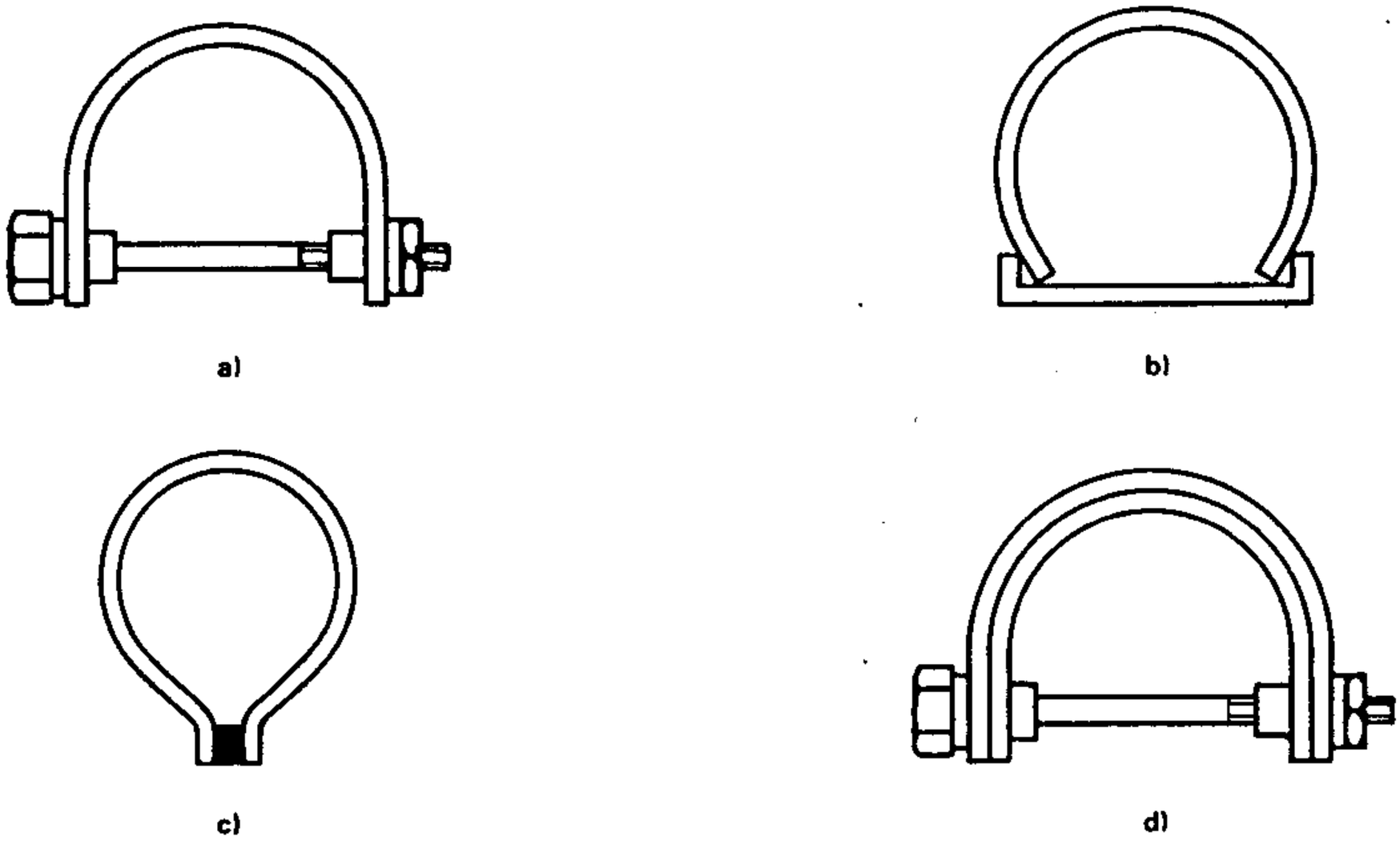

Figure 1 — Typical stressed U-bends

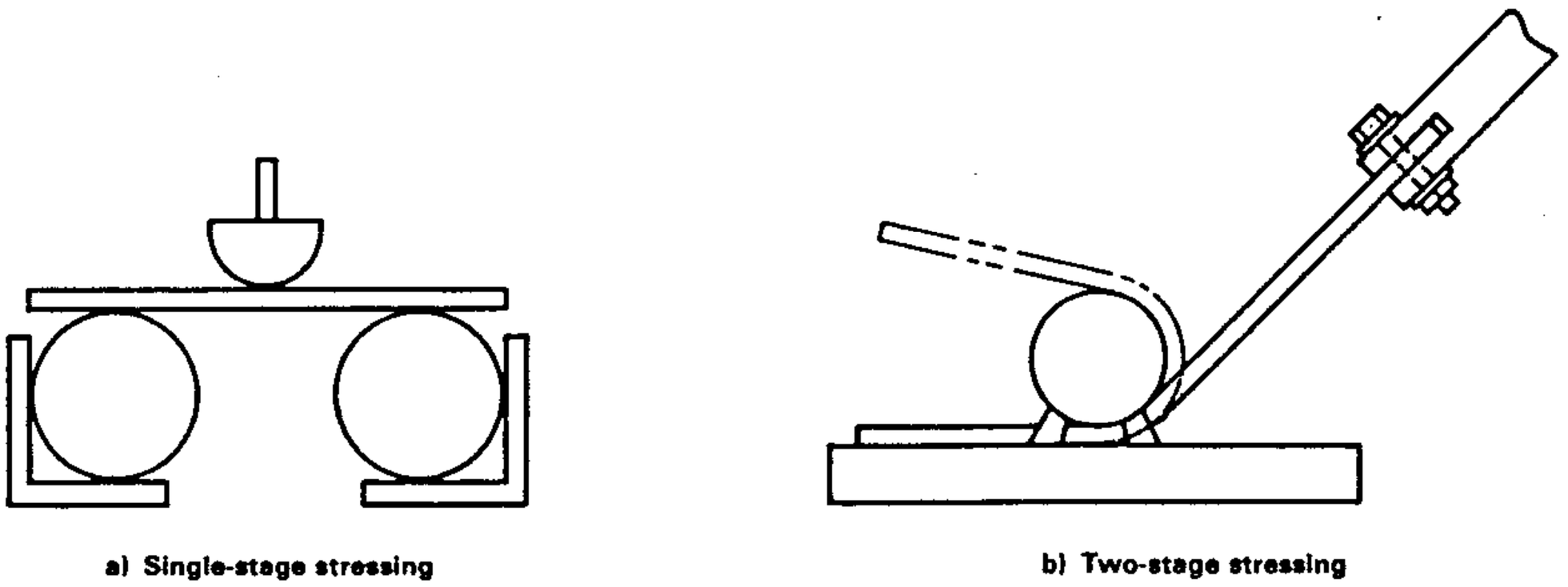

Figure 2 — Methods of stressing U-bend specimens

5.7 Specimens should be degreased prior to testing and should be handled with care thereafter.

5.8 Specimens should be examined, after forming, for cracks that may have developed before exposure to the test environment. It may also be desirable to prepare additional specimens for use as controls for later comparison (see 7.4).

5.9 Where it is necessary to mark the specimen for purposes of identification, the methods given in ISO 7539-1 should be followed.

6 Procedure

6.1 The aim should be to test under all likely service conditions and over a period which includes start-up, shut-down and other changes in conditions as well as the normal design conditions.

6.2 Interfaces between fluid phases represent likely areas for stress corrosion cracking as do locations where temperature gradients exist, where condensate may form or where local boiling may occur.

Locations where gradients may occur in the chemical composition of the fluid, especially in the concentration of oxidizing or reducing agents, also represent hazard areas. These factors should be taken into account when planning the location of specimens.

6.3 Location of specimens to permit safe examination and removal can be a major problem, especially with equipment under pressure, and may make it impossible to test all locations.

7 Assessment of results

7.1 Before specimens are examined it is necessary to check that relaxation of tension has not invalidated the test, for example by failure of the fastening.

7.2 Examination of specimens is generally by eye or low-power microscopy. In laboratory tests replicate specimens are frequently used to facilitate periodical examination and to determine exposure time when cracks are first observed. For in-service tests, the use of replicate specimens and regular examination is often impractical. In such cases, the specimens should be examined after an arbitrary exposure time sufficiently long to cover all anticipated variations in service conditions. A test period of 5 weeks to 10 weeks is often considered appropriate for process plant.

7.3 To open small cracks further stressing may be used. Metallographic sections through the specimen should be prepared to detect minor cracks.

7.4 Since some cracks may have origins other than stress corrosion it is necessary, if cracks are detected, to examine similarly stressed specimens that have not been exposed to the corroding environment for comparison.

7.5 The test should be regarded as basically a "go/no go" test and minor differences in behaviour, e.g. in time to first crack, or in size of crack, should not be considered significant.

7.6 Any cracking observed, unless positively proved to have occurred for some reason other than stress corrosion, should be considered as indicative of failure.

7.7 Lack of cracking in service tests, after a specified period of exposure, should be regarded as indicative of behaviour in practice only so long as the conditions of service are not appreciably altered from those existing during the test.

8 Test report

The test report should include the following information:

a) full description of the test material, including composition and structural conditions, type of product and section thickness from which specimens were taken;

b) orientation, type and size of test specimens and their surface preparation;

c) test environment, including location of specimens for in-service tests;

d) the times at which observations were made and when cracks became visible.

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