
**Corrosion of metals and alloys —
Methodology for determining
the resistance of metals to stress
corrosion cracking using the four-
point bend method**

*Corrosion des métaux et alliages — Méthodologie de détermination
de la résistance des métaux à la fissuration par corrosion sous
contrainte au moyen de la méthode de flexion quatre points*





COPYRIGHT PROTECTED DOCUMENT

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	1
5 Loading jig design	2
6 Specimen preparation	3
6.1 General.....	3
6.2 Parent material specimens.....	3
6.3 Welded specimens.....	4
6.4 Clad product specimens.....	5
7 Strain gauging	5
8 Loading	6
8.1 Strain level.....	6
8.2 Setting the total strain value.....	6
8.3 Testing at elevated temperature.....	8
9 Test environment	8
9.1 General.....	8
10 Procedure for four-point bend testing	9
11 Failure appraisal	10
11.1 Carbon steel.....	10
11.2 Corrosion resistant alloys.....	10
12 Test report	11
Annex A (informative) Surface preparation (see also ISO 7539-1)	12
Annex B (informative) Procedure for strain gauging and determining uniaxial stress-strain calibration curve	16
Bibliography	18

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 156, *Corrosion of metals and alloys*.

This International Standard is based on a draft NACE International standard on Four-Point Bend Testing of Materials for Oil and Gas applications. NACE International grants the right to ISO to reproduce material extracted from that document.

Introduction

This International Standard has been prepared as a sub-set of ISO 7539 which 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 precracked 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*

Corrosion of metals and alloys — Methodology for determining the resistance of metals to stress corrosion cracking using the four-point bend method

1 Scope

This International Standard provides guidelines for the use of four-point bend testing to evaluate the resistance of metals including carbon steel, low alloy steels, and corrosion resistant alloys (CRAs) to stress corrosion cracking. The method gives guidance on testing of both parent plate and welds and includes procedures for metals that have no distinct yield point in their stress-strain behaviour as well as metals with a distinct yield point. The emphasis in this International Standard is on the generic methodology of the four-point bend test. Service application will be varied and the relevant industry standard is to be consulted where appropriate.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 following terms and definitions apply.

3.1

corrosion resistant alloy

CRA

alloy designed to be resistant to general and localized corrosion in environments that are corrosive to carbon steel

3.2

heat affected zone

HAZ

portion of the base metal that is not melted during brazing, cutting, or welding, but whose microstructure and properties are altered by the heat of these processes

3.3

soft zone cracking

SZC

form of sulphide stress cracking that may occur when a steel contains a local “soft zone” of low yield strength material and is exposed under stress to environments containing H₂S

Note 1 to entry: Under service loads, soft zones may yield and accumulate plastic strain locally increasing the susceptibility to cracking of an otherwise cracking resistant material. Such soft zones are typically associated with welds in carbon steels.

4 Principle

The four-point bend test is a constant displacement test that is performed by supporting a beam specimen on two loading rollers (bearing cylinders) and applying a load through two other loading

rollers so that one face of the specimen is in tension (and uniformly stressed between the inner rollers) and the other is in compression. The stress at mid-thickness is zero and there will be significant gradients in stress through the thickness, this being most marked for thin specimens. As a consequence, cracks may initiate, but then arrest or their growth rate decrease. Hence, complete fracture might not always occur during the test exposure period. Important parameters are roller spacing, ratio between outer and inner span, specimen dimensions, width-to-thickness ratio, and roller diameter. Testing of as-welded specimens presents a particular challenge due to significant variations in root profile, surface roughness, extent of micro-cracks, and degree of misalignment.

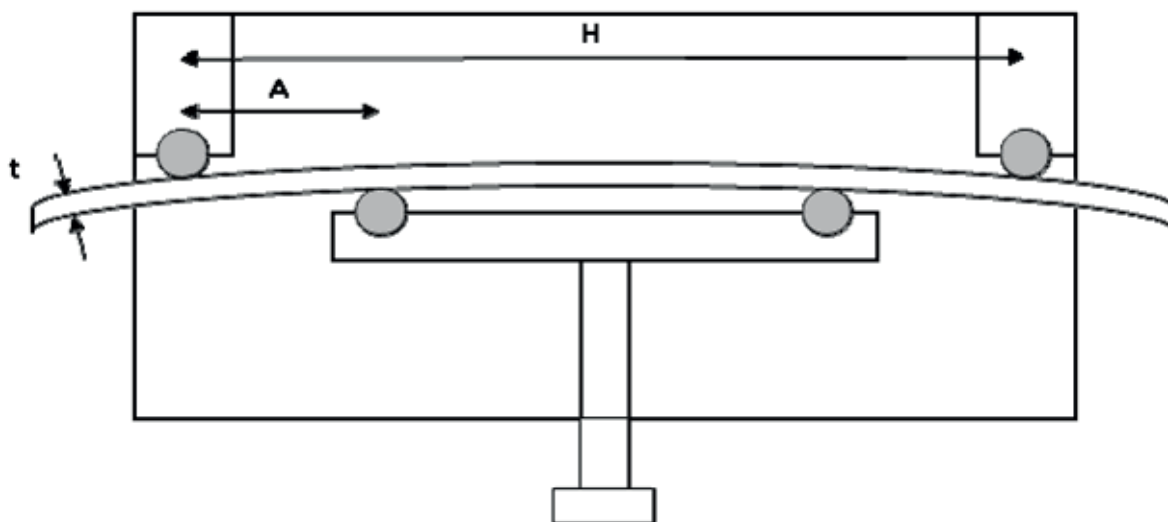
5 Loading jig design

5.1 A loading jig similar to that shown in [Figure 1](#) shall be used to apply a constant deflection to the specimen. The dimensions are often chosen so that $A = H/4$.

5.2 Specimens of thickness up to 5 mm present few problems for parent material specimens as they can be easily accommodated in test vessels of modest size with typical dimensions for the loading jig of the following:

- spacing between inner rollers: 50 mm-60 mm;
- spacing between outer rollers: 100 mm-130 mm;
- roller diameter: 6 mm-10 mm.

5.3 Thicker specimens, up to full wall thickness, are advisable for testing welded specimens. Here, there is a balance between minimizing the load by increasing the spacing between span supports and accommodating the increased size of the jig with possible constraints associated with the size of the test vessel. This is an individual judgement.



Key

- t specimen thickness
 A distance between the inner and outer supports
 H distance between the outer supports

Figure 1 — Typical four-point bend loading jig design