NACE TM0316-2016
Item No. 21404

Standard Test Method

Four-Point Bend Testing of Materials for Oil and Gas Applications

Approved 2015-12-03
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ISBN: 1-57590-339-3

Foreword

Four-point bend testing is used extensively in the oil and gas industry to evaluate resistance of metals to sulfide stress cracking and stress corrosion cracking. The surface of the specimen to be exposed to the environment in service is stressed in tension and the other surface in compression. The test is carried out for a specified exposure period with the specimen held under constant displacement using compact loading jigs. The compact nature of the jigs enables testing of several specimens in the test vessel simultaneously. Despite the apparent simplicity of the test, there are many factors that can influence the test results. The purpose of this standard is to establish a reliable methodology for conducting the tests to enhance repeatability and reproducibility of test data. The results of the tests can then be used with greater confidence to rank the performance of metals, the relative aggressiveness of environments, and to provide a basis for qualifying metals for service application. As such, the standard will be of particular benefit to materials and corrosion engineers in the oil and gas sector and to test houses providing critical data.

This standard was originally prepared in 2016 by Task Group 494, Four-Point Bend Test Method, which is administered by Specific Technology Group (STG) 32, Oil and Gas Production—Metallurgy. It is published under the auspices of STG 32.

In NACE standards, the terms *shall*, *must*, *should*, and *may* are used in accordance with the definitions of these terms in the *NACE Publications Style Manual*. The terms *shall* and *must* are used to state a requirement, and are considered mandatory. The term *should* is used to state something good and is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

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Contents

Section 1: General

1.1 This document 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 and sulfide stress cracking. The emphasis in this document is on the methodology of the four-point bend test. The context of the test results for service application is the responsibility of the end-user and is discussed in NACE MR0175/ISO[(1)] 15156.[1-3]

Section 2: Principle

2.1 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 reduce. Hence, complete fracture may 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.

Section 3: Loading Jig Design

3.1 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]

3.2 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:

Spacing between inner rollers: 40-60 mm;
Spacing between outer rollers: 90-130 mm;
Roller diameter: 5-10 mm.

3.2.1 Spacing in this context refers to the distance from the center of one roller to the center of the other roller.

3.2.2 These dimensions are indicative. Other sizes may be adopted provided they are fit for purpose.

3.3 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.

(1) International Organization for Standardization (ISO), Chemin de Blandonnet 8. Case Postale 401, 1214 Vermier, Geneva, Switzerland.