SLOVENSKI STANDARD
SIST EN 10229:2000

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Vrednotenje odpornosti jeklenih izdelkov proti vodikovi pokljivosti

Evaluation of resistance of steel products to hydrogen induced cracking

Bewertung der Beständigkeit von Stahlerzeugnissen gegen wasserstoffinduzierte Rißbildung (HIC)

Evaluation de la résistance des produits en acier a la fissuration induite par l'hydrogene (HIC)

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77.140.20	Visokokakovostna jekla	Stainless steels

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English version

Evaluation of resistance of steel products to hydrogen induced cracking (HIC)

Evaluation de la résistance des produits en acier à la fissuration induite par l'hydrogène (HIC)

Bewertung der Beständigkeit von Stahlerzeugnissen gegen wasserstoffinduzierte Rißbildung (HIC)

This European Standard was approved by CEN on 2 March 1998.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 1 "Steels - Mechanical and physical tests" the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by September 1998, and conflicting national standards shall be withdrawn at the latest by September 1998.

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

Introduction

The need, today, to drill deeper to find oil and natural gas and the procedures that are being used in many fields to enhance oil and gas recovery are resulting in an increase worldwide in the number of fields considered "sour". This in turn is leading to an increasing demand from oil companies for steels resistant to sour conditions. Flow lines or gathering pipelines in sour fields may be transporting crude oil or natural gas containing significant amounts of hydrogen sulphide (H_2S) and water. Additionally there is increased recognition of the importance of sour operating conditions in pressure vessels and structural steel work.

On steel, the presence of water with H_2S can cause corrosion. Atomic hydrogen generated by the corrosion reaction can be absorbed into the steel and lead to cracking of the product. Cracks on adjacent planes may link up to form through thickness "steps" and in some instances surface blistering may occur. Hydrogen induced crackings occurs (HIC) without any applied stresses.

The test described in this European Standard is not intended to duplicate service conditions, nor show how a material will perform in service. It is an accelerated corrosion test designed as a reproducible procedure capable of evaluating the resistance to hydrogen induced cracking.

NOTE : A draft "Corrosion Protection - Carbon and allow steels for use in H_2S containing environments in oil and gas production - Materials requirements and test method" being currently prepared by CEN/TC 262 "Protection of metallic materials against corrosion" uses also the term "Step wise cracking (SWC)".

1 Scope

This standard specifies a method of evaluation of the susceptibility to hydrogen induced cracking (HIC) of steel products with nominal thicknesses equal to or greater than 6 mm.

NOTE : This standard may be applied by agreement to products with nominal thicknesses lower than 6 mm.

This standard does not cover resistance to other types of corrosion such as for example stress corrosion cracking.

2 Definitions

For the purposes of this standard, the following definitions apply.

2.1 sample

A sufficient quantity of material taken from the product for the purpose of producing three test pieces, for example : Ring in case of tubes, part of plates.

2.2 test piece

Part of the sample with specified dimensions, machined for submission to the test.

2.3 section

The part which is cut from each test piece after testing, metallographically prepared and examined in order to assess the cracking present. Three sections are taken per test piece.

2.4 crack

A more or less planar void discontinuity in the steel.

2.5 hydrogen induced crack

A crack below and approximately parallel to the surface of the product, initiated and propagated by the action of hydrogen in the steel as a result of contact with a wet sour medium.

2.6 separation between cracks

The shortest straight line distance between two cracks.

2.7 isolated crack

A crack separated from the next crack by more than 0,50 mm, with a minimum length equal or greater than 0,1 mm (see figures 1 and 2).

2.8 crack system

A combination of two or more cracks, each of which is within 0,50 mm of next crack (see figures 1 and 2).

2.9 extent of cracking

The magnitudes of the longitudinal and transverse components of a crack or crack system are referred to as "the longitudinal extent of cracking E_{LC}" and "the transverse extent of cracking E_{TC}", respectively (see figure 1).

NOTE : All hydrogen induced crack systems have longitudinal and transverse components.

2.10 stepwise crack

Crack system in which the transverse component is equal to or greater than 0,1 mm.

3 Principle of the method

The method consists of exposing test pieces without any applied stress to a corrosive medium for a period of 96 h followed by evaluation of the test pieces. The corrosive medium is a H_2S saturated solution which may be either an acidified sodium chloride solution (test solution A see 4.1) or a synthetic seawater (test solution B see 4.2). Other intermediate solutions may also be agreed between purchaser and supplier.

4 Test solutions

4.1 Test solution A

The acidified sodium chloride solution shall be prepared by dissolving 50 g of sodium chloride (NaCl) and 5 g of glacial acetic acid (CH_3COOH) in 945 ml of water. The initial pH shall be 2,7 ± 0,1 before H_2S is introduced.

4.2 Test solution B (synthetic seawater)

To prepare 10,0 l of synthetic seawater, dissolve 245,34 g of sodium chloride (NaCl) and 40,94 g of anhydrous sodium sulfate (Na_2SO_4) in 8 l to 9 l of water. Add slowly with vigorous stirring, 200 ml of solution B1 and then 100 ml of solution B2. Dilute to 10,0 l with distilled or deionized water. Adjust the pH to 8,2 ± 0,1 with 0,1 M sodium hydroxide (NaOH) solution or 0,1 M hydrochloric acid (HCl) before H_2S is introduced (see note).

NOTE : Only a few millilitres of NaOH solution should be required.

a) Solution B1

The solution shall be prepared by dissolving the indicated amounts of the following salts in water and dilute to a total volume of 7,0 l :

$MgCl_2, 6 H_20$	:	3 889,0 g	(= 555,6 g/l)
$CaCl_2$ (anhydrous)	:	405,6 g	(= 57,9 g/l)
$SrCl_2, 6 H_20$	:	14,8 g	(= 2,1 g/l)

The solution shall be stored in well-stoppered glass or other chemically inert material containers for a time not exceeding 6 months.

b) Solution B2

The solution shall be prepared by dissolving the indicated amounts of the following salts in water and dilute to a total volume of 7,0 l :

KCl	486,2 g	(= 69,5 g/l)
$NaHCO_3$	140,7 g	(= 20,1 g/l)
KBr	70,4 g	(= 10,0 g/l)
BO_3H_3	19,0 g	(= 2,7 g/l)
NaF	2,1 g	(= 0,3 g/l)

The solution shall be stored in well-stoppered glass or other chemically inert material containers for a time not exceeding 6 months.

4.3 Volume ratio

The ratio of the volume of test solution to the total surface area of the test pieces shall be between 3 ml/cm² and 6 ml/cm².

4.4 Reagent purity

The purity of the gases shall be 99,5 % minimum per volume.

All chemicals shall be of reagent quality.

The water shall be distilled or deionized.

NOTE : The conductivity of the water should not normally exceed 5 µS/cm.

5 Apparatus

Testing shall be carried out in apparatus which meets the specific requirements for HIC tests and shall take full account of the safety procedures necessary when using toxic hydrogen sulphide gas.

The basic equipment of the apparatus shall include the following :

- a test vessel and supports made of chemically inert material such glass or polytetrafluorethylene (PTFE) ;

- equipment to maintain the standard temperature during the test ;

- devices to measure gas flow rates ;

- a trap to avoid backstreaming of air which could give oxygen contamination of the test atmosphere. This could be, for instance, a vessel with sodium hydroxide solution to bind the surplus H_2S.

6 Test Pieces

6.1 Location and orientation

6.1.1 Samples from which the test pieces will be machined shall be removed from the material to be assessed by any appropriate method. If the samples are flame cut, they shall be of sufficient size such that test pieces can be machined well away from the heat affected zones.