SLOVENSKI STANDARD
SIST EN ISO 15156-3:2004

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Petroleum, petrochemical and natural gas industries - Materials for use in H2S-containing environments in oil and gas production - Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys (ISO 15156-3:2003)

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Erdöl- und Erdgasindustrie - Werkstoffe für den Einsatz in H2S-haltiger Umgebung bei der Öl- und Gasgewinnung - Teil 3: Hochlegierte Stähle (CRAs) und andere Legierungen (ISO 15156-3:2003)

Industries du pétrole, pétrochimiques et du gaz naturel - Matériaux pour utilisation dans des environnements contenant de l'hydrogene sulfuré (H2S) dans la production de pétrole et de gaz - Partie 3: ARC (alliages résistants a la corrosion) et autres alliages résistants a la fissuration (ISO 15156-3:2003)

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77.060	Korozija kovin	Corrosion of metals

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Petroleum, petrochemical and natural gas industries - Materials for use in H_2S-containing environments in oil and gas production - Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys (ISO 15156-3:2003)

Industries du pétrole, pétrochimiques et du gaz naturel - Matériaux pour utilisation dans des environnements contenant de l'hydrogène sulfuré (H_2S) dans la production de pétrole et de gaz - Partie 3: ARC (alliages résistants à la corrosion) et autres alliages résistants à la fissuration (ISO 15156-3:2003)

This European Standard was approved by CEN on 2 December 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN ISO 15156-3:2003) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum and natural gas industries", 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 June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

NOTE FROM CMC The foreword is susceptible to be amended on reception of the German language version. The confirmed or amended foreword, and when appropriate, the normative annex ZA for the references to international publications with their relevant European publications will be circulated with the German version.

Endorsement notice

The text of ISO 15156-3:2003 has been approved by CEN as EN ISO 15156-3:2003 without any modifications.

INTERNATIONAL STANDARD

ISO 15156-3

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2003-12-15

Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production —

Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys

Industries du pétrole et du gaz naturel — Matériaux pour utilisation dans des environnements contenant de l'hydrogène sulfuré (H_2S) dans la production de pétrole et de gaz —

Partie 3: ARC (alliages résistants à la corrosion) et autres alliages résistants à la fissuration

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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.

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.

ISO 15156-3 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*.

ISO 15156 consists of the following parts, under the general title *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production*:

— *Part 1: General principles for selection of cracking-resistant materials*

— *Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons*

— *Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

Introduction

The consequences of sudden failures of metallic oil and gas field components, associated with their exposure to H_2S-containing production fluids, led to the preparation of the first edition of NACE MR0175, which was published in 1975 by the National Association of Corrosion Engineers, now known as NACE International.

The original and subsequent editions of NACE MR0175 established limits of H_2S partial pressure above which precautions against sulfide stress-cracking (SSC) were always considered necessary. They also provided guidance for the selection and specification of SSC-resistant materials when the H_2S thresholds were exceeded. In more recent editions, NACE MR0175 has also provided application limits for some corrosion-resistant alloys, in terms of environmental composition and pH, temperature and H_2S partial pressures. NACE MR0175 is complemented by NACE TM0177-96 and NACE TM0284 test methods.

In separate developments, the European Federation of Corrosion issued EFC Publication Number 16 in 1995 and EFC Publication Number 17 in 1996. These documents are generally complementary to those of NACE, though they differ in scope and detail.

This part of ISO 15156 utilises the above sources to provide requirements and recommendations for materials qualification and selection for application in environments containing wet H_2S in oil and gas production systems.

Changes will be incorporated into this International Standard by amendments or revisions in accordance with *Interpretation and maintenance of ISO 15156* by ISO/TC 67/WG 7, copies of which can be obtained from the ISO/TC 67 Secretariat. Experts from both NACE and EFC are members of ISO/TC 67/WG 7.

Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production —

Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys

WARNING — CRAs (corrosion-resistant alloys) and other alloys selected using this part of ISO 15156 are resistant to cracking in defined H_2S-containing environments in oil and gas production but not necessarily immune to cracking under all service conditions. It is the equipment user's responsibility to select the CRAs and other alloys suitable for the intended service.

1 Scope

This part of ISO 15156 gives requirements and recommendations for the selection and qualification of CRAs (corrosion-resistant alloys) and other alloys for service in equipment, used in oil and natural gas production and natural gas treatment plants in H_2S-containing environments, whose failure could pose a risk to the health and safety of the public and personnel or to the environment. It can be applied to help to avoid costly corrosion damage to the equipment itself. It supplements, but does not replace, the materials' requirements of the appropriate design codes, standards or regulations.

This part of ISO 15156 addresses the resistance of these materials to damage that may be caused by sulfide stress-cracking (SSC), stress-corrosion cracking (SCC) and galvanically-induced hydrogen stress-cracking (GHSC).

This part of ISO 15156 is only concerned with cracking. Loss of material by general (mass loss) or localized corrosion is not addressed.

Table 1 provides a non-exhaustive list of equipment to which this part of ISO 15156 is applicable, including permitted exclusions.

This part of ISO 15156 applies to the qualification and selection of materials for equipment designed and constructed using conventional elastic design criteria. For designs utilizing plastic criteria (e.g. strain-based and limit-state designs), see ISO 15156-1:2001, Clause 5.

This part of ISO 15156 is not necessarily suitable for application to equipment used in refining or downstream processes and equipment.

Table 1 — List of equipment

ISO 15156 is applicable to materials used for the following equipment	Permitted exclusions
Drilling, well construction and well-servicing equipment	Equipment only exposed to drilling fluids of controlled composition[a] Drill bits Blowout Preventer (BOP) shear blades[b] Drilling riser systems Work strings Wireline and wireline equipment[c] Surface and intermediate casing
Wells, including subsurface equipment, gas lift equipment, wellheads and christmas trees	Sucker rod pumps and sucker rods[d] Electric submersible pumps Other artificial lift equipment Slips
Flow-lines, gathering lines, field facilities and field processing plants	Crude oil storage and handling facilities operating at a total absolute pressure below 0,45 MPa (65 psi)
Water-handling equipment	Water-handling facilities operating at a total absolute pressure below 0,45 MPa (65 psi)
Natural gas treatment plants	
Transportation pipelines for liquids, gases and multiphase fluids	Lines handling gas prepared for general commercial and domestic use
For all equipment above	Components loaded only in compression

[a] See ISO 15156-2:2003, A.2.3.2.3 for more information.

[b] See ISO 15156-2:2003, A.2.3.2.1 for more information.

[c] Wireline lubricators and lubricator connecting devices are not permitted exclusions.

[d] For sucker rod pumps and sucker rods, reference can be made to NACE MR0176.

2 Normative references

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

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test —Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 10423, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment*

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 15156-1:2001, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

ISO 15156-2:2003, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons*

ASTM A 747/A 747M[1] , *Standard specification for steel castings, stainless, precipitation hardening*

EFC Publications Number 17[2] , *Corrosion resistant alloys for oil and gas production: guidelines on general requirements and test methods for H_2S in service*

NACE CORROSION/95[3] , Paper 47, (Houston), 1995, *Test methodology for elemental sulfur-resistant advanced materials for oil and gas field equipment,* by G. Steinbeck, W. Bruckhoff, M. Köhler, H. Schlerkmann, G. Schmitt

NACE TM0177-96, *Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in H_2S environments*

SAE[4] – ASTM, *Metals and alloys in the Unified Numbering System, ISBN 0-7680-04074*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15156-1 and ISO 15156-2 and the following apply.

3.1
ageing
change in metallurgical properties that generally occurs slowly at room temperature (natural ageing) and more rapidly at higher temperature (artificial ageing)

3.2
anneal
heat to and hold at a temperature appropriate for the specific material and then cool at a suitable rate, for such purposes as reducing hardness, improving machineability, or obtaining desired properties

3.3
austenite
face-centred cubic crystalline phase of iron-base alloys

3.4
duplex stainless steel
austenitic/ferritic stainless steel
stainless steel whose microstructure at room temperature consists primarily of a mixture of austenite and ferrite

3.5
ferrite
body-centred cubic crystalline phase of iron-base alloys

1) ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA

2) European Federation for Corrosion, available from The Institute of Materials, 1 Carlton House Terrace, London SW1Y 5DB, UK [ISBN 0-901716-95-2]

3) NACE International, P.O. Box 2183140, Houston, TX 77218-8340, USA

4) Society of Automotive Engineers (SAE), 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA

3.6
ferritic stainless steel
stainless steel whose microstructure, at room temperature, consists predominantly of ferrite

3.7
galvanically-induced hydrogen stress-cracking
GHSC
cracking that results due to the presence of hydrogen in a metal, induced in the cathode of a galvanic couple, and tensile stress (residual and/or applied)

3.8
martensite
hard, supersaturated solid solution of carbon in iron characterized by an acicular (needle-like) microstructure

3.9
martensitic steel
steel in which a microstructure of martensite can be attained by quenching at a cooling rate fast enough to avoid the formation of other microstructures

3.10
pitting resistance equivalent number
PREN
F_{PREN}
number, developed to reflect and predict the pitting resistance of a CRA, based upon the proportions of Cr, Mo, W and N in the chemical composition of the alloy

NOTE See 6.3 for further information.

3.11
solid solution
single crystalline phase containing two or more elements

3.12
stainless steel
steel containing 10,5 % or more chromium, possibly with other elements added to secure special properties

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms shown in ISO 15156-1 and ISO 15156-2 apply, some of which are repeated for the purpose of convenience, together with the following:

AYS actual yield strength

CRA corrosion-resistant alloy

HBW Brinell hardness

HRB Rockwell hardness (scale B)

HRC Rockwell hardness (scale C)

p_{CO_2} partial pressure of CO_2

p_{H_2S} partial pressure of H_2S

PWHT post-weld heat treatment

S^0 elemental sulfur

RSRT rippled strain rate test

SSRT slow strain rate test

UNS unified (alloy) numbering system

5 Factors affecting the cracking resistance of CRAs and other alloys in H_2S-containing environments

The cracking behavior of CRAs and other alloys in H_2S-containing environments can be affected by complex interactions of parameters, including the following:

— chemical composition, strength, heat treatment, microstructure, method of manufacture and finished condition of the material;

— H_2S partial pressure or equivalent dissolved concentration in the water phase;

— acidity (*in situ* pH) of the water phase;

— chloride or other halide ion concentration;

— presence of oxygen, sulfur or other oxidants;

— exposure temperature;

— pitting resistance of the material in the service environment;

— galvanic effects;

— total tensile stress (applied plus residual);

— exposure time.

These factors shall be considered when using this part of ISO 15156 for the selection of materials suitable for environments containing H_2S in oil and gas production systems.

6 Qualification and selection of CRAs and other alloys with respect to SSC, SCC and GHSC in H_2S-containing environments

6.1 General

CRAs and other alloys shall be selected for their resistance to SSC, SCC and/or GHSC as required by the intended service.

Compliance of a CRA or other alloy with this part of ISO 15156 implies cracking resistance within defined environmental service limits. These limits are dependent on the material type or the individual alloy.

To enable qualification and/or selection of CRAs and other alloys, the equipment purchaser may be required to provide information on the proposed conditions of exposure to the equipment supplier.

In defining the severity of H_2S-containing environments, exposures that might occur during system upsets or shutdowns, etc. shall also be considered. Such exposures can include unbuffered, low pH, condensed water