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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

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 2: Aciers au carbone et aciers faiblement alliés résistants à la fissuration, et utilisation de fontes

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.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 15156-2:2015), which has been technically revised. The main changes compared to the previous edition are as follows:

— corrections of temperature conversion for welding (see A.2.1.4), vold deformation and stress relief (see A.2.1.6), identification stamping (see A.2.1.9), tubulars and tubular components (see A.2.2.3.4), compressor impellers (see A.2.3.3.2);

— title change from Shear rams to Rams in A.2.3.2.2;

— addition of C110 and changes the designation of C95 to R95 in Table A.3;

— reference change to NACE TM0316 in Table B.1;

— addition of reference to BS 8701 in B.4.3;

— changes and additions to Table B.3;

— modification of Annex C to include alternative parameters and expanded explanation for the use of chemical activity and fugacity, and to provide some general guidance for the use of thermodynamic modeling for the determination of environmental severity.

A list of all parts in the ISO 15156 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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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.

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

In 2003, the publication of the ISO 15156-series and NACE MR0175/ISO 15156 was completed for the first time. These technically identical documents utilized 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. They are complemented by NACE TM0177 and NACE TM0284 test methods.

The revision of this document, i.e. ISO 15156-2,involves a consolidation of all changes agreed and published in the Technical Circular 1, ISO 15156-2:2015/Cir.1:2017, the Technical Circular 2, ISO 15156-2:2015/Cir.2:2018 and the Technical Circular 3, ISO 15156-2:2015/Cir.3:2019, published by the ISO 15156 series Maintenance Agency secretariat at DIN.

The changes were developed by and approved by the ballot of, representative groups from within the oil and gas production industry. The great majority of these changes stem from issues raised by document users. A description of the process by which these changes were approved can be found at the ISO 15156 series maintenance website: www.iso.org/iso15156maintenance.

When found necessary by oil and gas production industry experts, future interim changes to this document will be processed in the same way and will lead to interim updates to this document in the form of Technical Corrigenda or Technical Circulars. Document users should be aware that such documents can exist and can impact the validity of the dated references in this document.

The ISO 15156 series Maintenance Agency at DIN was set up after approval by the ISO Technical Management Board given in document 34/2007. This document describes the make up of the agency, which includes experts from NACE, EFC and ISO/TC 67, and the process for approval of amendments. It is available from the ISO 15156 series maintenance website and from the ISO/TC 67 Secretariat. The website also provides access to related documents that provide more detail of the ISO 15156 series maintenance activities.

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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

WARNING — Carbon and low-alloy steels and cast irons selected using this document 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 carbon and low alloy steels and cast irons suitable for the intended service.

1 Scope

This document gives requirements and recommendations for the selection and qualification of carbon and low-alloy steels for service in equipment used in oil and natural gas production and natural gas treatment plants in H_2S-containing environments, whose failure can 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 document addresses the resistance of these steels to damage that can be caused by sulfide stress cracking (SSC) and the related phenomena of stress-oriented hydrogen-induced cracking (SOHIC) and soft-zone cracking (SZC).

This document also addresses the resistance of these steels to hydrogen-induced cracking (HIC) and its possible development into stepwise cracking (SWC).

This document is concerned only 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 document is applicable, including exclusions.

This document applies to the qualification and selection of materials for equipment designed and constructed using load controlled design methods. For design utilizing strain-based design methods, see ISO 15156-1:2020, Clause 5.

Annex A lists SSC-resistant carbon and low alloy steels, and A.2.4 includes requirements for the use of cast irons.

This document is not necessarily suitable for application to equipment used in refining or downstream processes and equipment.

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Table 1 — List of equipment

This document is applicable to materials used for the following equipment	Exclusions
Drilling, well construction and well-servicing equipment	Equipment exposed only 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)
	Water injection and water disposal equipment
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 A.2.3.2.3 for more information.

[b] See A.2.3.2.1 for more information.

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

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6506 (all parts), *Metallic materials — Brinell hardness test*

ISO 6507 (all parts), *Metallic materials — Vickers hardness test*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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

ISO 15156-1:2020, *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 15156-3, *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*

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NACE TM0177[1)], *Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in H_2S environments*

NACE TM0284, *Evaluation of pipeline and pressure vessel steels for resistance to hydrogen-induced cracking*

NACE TM0316, *Four-point bend testing of materials for oil and gas applications*

SAE AMS-2430[2)], *Shot Peening*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
Brinell hardness
HBW
hardness value of a material measured normally using a 10 mm diameter tungsten carbide ball indenter with a force of 29,42 kN

Note 1 to entry: The measurement shall be in accordance with the ISO 6506 series. Here, ASTM E10 is equivalent to ISO 6506-1.

3.2
bubble-point pressure
p_B
pressure under which gas bubbles form in a liquid at a particular operating temperature

Note 1 to entry: See C.2.

3.3
burnishing
process of smoothing surfaces using frictional contact between the material and some other hard pieces of material, such as hardened steel balls

3.4
casting
metal that is obtained at or near its finished shape by the solidification of molten metal in a mould

3.5
cast iron
iron-carbon alloy containing approximately 2 % to 4 % mass fraction carbon

3.5.1
grey cast iron
cast iron that displays a grey fracture surface due to the presence of flake graphite

3.5.2
white cast iron
cast iron that displays a white fracture surface due to the presence of cementite

1) www.nace.org

2) www.sae.org

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3.5.3
malleable iron
white cast iron that is thermally treated to convert most or all of the cementite to graphite (temper carbon)

3.5.4
ductile iron
nodular cast iron
cast iron that has been treated while molten with an element (usually magnesium or cerium) that spheroidizes the graphite

3.6
cementite
microstructural constituent of steels composed principally of iron carbide (Fe_3C)

3.7
cold deforming
cold forging
cold forming
cold working
deforming metal plastically under conditions of temperature and strain rate that induce strain-hardening, usually, but not necessarily, conducted at room temperature

3.8
fitness-for-purpose
suitability for use under the expected service conditions

3.9
free-machining steel
steel to which elements such as sulfur, selenium and lead have been added intentionally to improve machineability

3.10
lower critical temperature
temperature of a ferrous metal at which austenite begins to form during heating or at which the transformation of austenite is completed during cooling

3.11
nitriding
case-hardening process in which nitrogen is introduced into the surface of metallic materials (most commonly ferrous alloys)

EXAMPLE Liquid nitriding, gas nitriding, ion nitriding and plasma nitriding.

3.12
normalize
heating a ferrous metal to a suitable temperature above the transformation range (austenitizing), holding at temperature for a suitable time and then cooling in still air (or protective atmosphere) to a temperature substantially below the transformation range

3.13
plastically deformed
permanently deformed by stressing beyond the limit of elasticity, i.e. the limit of proportionality of stress to strain

3.14
pressure-containing part
part whose failure to function as intended results in a release of retained fluid to the atmosphere

EXAMPLE Valve bodies, bonnets and stems.

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3.15
quenched and tempered
quench hardened and then tempered

3.16
Rockwell C hardness
HRC
hardness value of a material measured using a Rockwell C diamond cone indenter with a force of 1 471 N

Note 1 to entry: The measurement shall be in accordance with the ISO 6508 series. Here, ASTM E18 is equivalent to ISO 6508-1.

3.17
shot-peening
inducing compressive stresses in the surface layer of a material by bombarding it with a selected medium (usually round steel shot) under controlled conditions

3.18
stress relief
heating a metal to a suitable temperature, holding at that temperature long enough to reduce residual stresses, and then cooling slowly enough to minimize the development of new residual stresses

3.19
tempering
heat treatment by heating to a temperature below the lower critical temperature, for the purpose of decreasing the hardness and increasing the toughness of hardened steel, hardened cast iron and, sometimes, normalized steel

3.20
tensile strength
ultimate strength
ratio of maximum load to original cross-sectional area

Note 1 to entry: See ISO 6892-1.

3.21
test batch
group of items representing a production batch whose conformity with a specified requirement can be determined by testing representative samples in accordance with a defined procedure

3.22
tubular component
cylindrical component (pipe) having a longitudinal hole, used in drilling/production operations for conveying fluids

3.23
Vickers hardness
HV
hardness value of a material using a diamond pyramid indenter and one of a variety of possible applied loads

Note 1 to entry: The measurement shall be in accordance with the ISO 6507 series. Here, ASTM E384 is equivalent to ISO 6507-1.

3.24
weldment
portion of a component on which welding has been performed, including the weld metal, the heat-affected zone, and the adjacent parent metal

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