INTERNATIONAL STANDARD

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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

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 1: Principes généraux pour le choix des matériaux résistant à la fissuration

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 15156-1:2015), which has been technically revised. The main changes compared to the previous edition are as follows:

— new definition on "galvanically induced hydrogen stress cracking" (see 3.14), "chemical activity" (see 3.27) and "fugacity" (see 3.28);

— inclusion of an expanded description of factors affecting the susceptibility of materials to cracking caused by H_2S. The expanded description includes specific guidance provided in ISO 15156-2:2020, Annex C for gas phase containing systems using H_2S fugacity (as an alternative to H_2S partial pressure) and application of non-ideal thermodynamic rules for gas-free liquid systems.

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.

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 15156-1, involves a consolidation of all changes agreed and published in the Technical Circular 1, ISO 15156-1:2015/Cir.1:2017, 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 makeup 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.

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

WARNING — Metallic materials 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 materials suitable for the intended service.

1 Scope

This document describes general principles and gives requirements and recommendations for the selection and qualification of metallic materials for service in equipment used in oil and gas production and in natural-gas sweetening plants in H_2S-containing environments, where the failure of such equipment 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 given in the appropriate design codes, standards, or regulations.

This document addresses all mechanisms of cracking that can be caused by H_2S, including sulfide stress cracking, stress corrosion cracking, hydrogen-induced cracking and stepwise cracking, stress-oriented hydrogen-induced cracking, soft zone cracking, and galvanically induced hydrogen stress cracking.

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 Clause 5.

This document is not necessarily applicable to equipment used in refining or downstream processes and equipment.

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
Flowlines, 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 ISO 15156-2:2020, A.2.3.2.3 for more information.

[b] See ISO 15156-2:2020, 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 15156-2, *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*

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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
blowout preventer
BOP
mechanical device capable of containing pressure, used for control of well fluids and drilling fluids during drilling operations

3.2
brazing
joining metals by flowing a thin layer (of capillary thickness) of a lower-melting-point non-ferrous filler metal in the space between them

3.3
carbon steel
alloy of carbon and iron containing up to 2 % mass fraction carbon and up to 1,65 % mass fraction manganese and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminium)

Note 1 to entry: Carbon steels used in the petroleum industry usually contain less than 0,8 % mass fraction carbon.

3.4
christmas tree
equipment at a wellhead for the control of fluid production or injection

3.5
cold work
plastic deformation of metal under conditions of temperature and strain rate that induce strain hardening, usually, but not necessarily, conducted at room temperature

3.6
corrosion-resistant alloy
CRA
alloy intended to be resistant to general and localized corrosion of oilfield environments that are corrosive to *carbon steels* (3.3)

3.7
ferrite
body-centred cubic crystalline phase of iron-based alloys

3.8
ferritic steel
steel whose *microstructure* (3.16) at room temperature consists predominantly of *ferrite* (3.7)

3.9
hardness
resistance of metal to plastic deformation, usually measured by indentation

3.10
heat-affected zone
HAZ
portion of the base metal that is not melted during brazing, cutting, or welding, but whose *microstructure* (3.16) and properties are altered by the heat of these processes

3.11
heat treatment
heating and cooling a solid metal or alloy in such a way as to obtain desired properties

Note 1 to entry: Heating for the sole purpose of hot working is not considered heat treatment.