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Petroleum and natural gas offshore platforms — Guidelines for materials selection for high content CO₂ environment for casings, tubings and downhole equipment

Industries du pétrole et du gaz naturel — Choix de matériaux dans un environnement CO₂ pour les tubes sans soudure et accessoires pour utilisation en tant que tube de cuvelage, de production et équipements de fond — Lignes directrices

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This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

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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.

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ISO 17348 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

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Introduction

This International standard gives recommendations and guidelines for materials selection in oil and gas production wells, specifically for high content CO₂ gas injection and production systems, as for Water Alternating Gas (WAG) injection systems. It is intended to enable responsible parties to carry out materials selection in a consistent manner as a part of the engineering work, based upon a design basis for a particular installation. The main users of this standard are Oil and Gas Production Companies and engineering contractors. Material manufacturers and equipment suppliers may benefit from using this standard for their product development.

Carbon Capture and Storage (CCS) has been identified as an important technology for achieving a significant reduction in CO₂ emissions to the atmosphere.

Many of the technologies and practices that have been developed for CO₂ enhanced oil recovery (EOR) may have applicability in CCS projects, recognizing however, that each project should be designed to meet its site specific conditions. The CO₂ EOR experiences of the oil and gas industry represent the largest collective base of technical information available on CO₂ injection and, as such, provide valuable information for development and implementation of CCS field projects as they move forward.

This International standard does not provide detailed material requirements and recommendations for manufacturing and testing of equipment. Such information may be found in particular product standards and in manufacturing and testing standards. Other International standards related to material usage limitations are referred to e.g. ISO 15156 for H₂S containing service.

In case of conflict between this International Standard and other international product standards, the requirements of the latter shall take precedence.

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Petroleum and natural gas offshore platforms — Guidelines for materials selection for high content CO₂ environment for casings, tubings and downhole equipment

1 Scope

This international standard provides guidelines for material selection of seamless casing and tubing and downhole equipment of CO₂ gas injection wells and production wells in high pressure and high content CO₂ environments (above 10 % molar of CO₂ and 1 MPa of CO₂ Partial pressure). This international standard only considers materials compatibility with the environment.

Guidance is given for the following:

- corrosion evaluation;
- materials selection;
- corrosion control.

The guidance in this standard is aimed at high CO₂ wells, where the threat of low pH and CO₂ corrosion is greatest. However, many aspects are equally applicable to environments containing lower CO₂ concentrations.

Materials selection is influenced by many factors and synergies and should be performed by an experienced materials engineer.

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

ISO 13680, *Petroleum and natural gas industries — Corrosion-resistant alloy seamless tubes for use as casing, tubing and coupling stock — Technical delivery conditions*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

ISO 21457, *Petroleum, petrochemical and natural gas industries — Materials selection and corrosion control for oil and gas production systems*

ISO 23936-1, *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 1: Thermoplastics*

ISO 23936-2, *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 2: Elastomers*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply

3.1.1

annulus

space between consecutive, concentric, pipe strings, such as between casings or between casing and tubing

3.1.2

casing

pipe run from the surface and intended to line the walls of a drilled well as defined in ISO 11960

3.1.3

cross overs

a short subassembly used to enable two components with different thread types or sizes to be connected

3.1.4

dense phase

the fluid state (supercritical or liquid) above critical pressure

3.1.5

dry gas

a gas that does not have water as a liquid phase at given operational conditions e.g temperature above dew point

3.1.6

gas production wells

wells where the gas/liquid ratio is between 900 and 18 000 for condensate gas, and higher than 18 000 for dry gas

3.1.7

intermediate casing

a string that is set between the surface casing and production casing. There may be more than one intermediate casing, enabling getting deeper in the well

3.1.8

packer

mechanical device, not installed in a designed receptacle, used for blocking fluid (liquid or gas) communication through the annular space between conduits by sealing off the space between them as defined in ISO 14310

3.1.9

pitting resistance equivalent number

PREN

number, developed to reflect and predict the pitting resistance of a stainless steel, based upon the proportions of Cr, Mo, W and N in the chemical composition of the alloy

Note 1 to entry: For the purposes of this International Standard, PREN is calculated from Equation:

$$\text{PREN} = w\text{Cr} + 3.3 (w\text{Mo} + 0.5w\text{W}) + 16w\text{N}$$

where

wCr is the percent (mass fraction) of chromium in the alloy;

wMo is the percent (mass fraction) of molybdenum in the alloy;

wW is the percent (mass fraction) of tungsten in the alloy;

wN is the percent (mass fraction) of nitrogen in the alloy.

3.1.10**production casing**

pipe run from the surface and intended to line the walls of a drilled well, isolating production zone and/or injection zone

3.1.11**pup joints**

casing or tubing of length shorter than Range 1 as defined in ISO 11960

3.1.12**rapid gas decompression****RGD****explosive decompression**

rapid pressure-drop in a high pressure gas-containing system which disrupts the equilibrium between external gas pressure and the concentration of gas dissolved inside any polymer, with the result that excess gas tries to escape from the solution at points throughout the material, causing expansion as defined in ISO 23936-2

Note 1 to entry: If large enough and if the pressure-drop rate is faster than the natural gas diffusion rate, blistering or rupturing can occur.

3.1.13**shoe**

assembly screwed to the casing with a rounded profile, in order to guide the casing string throughout the wellbore

3.1.14**slickline**

a thin nonelectric cable used for selective placement and retrieval of wellbore hardware, such as plugs, gauges and valves located in sidepocket mandrels

3.1.15**supercritical state**

the fluid state above critical pressure and temperature

3.1.16**surface casing**

a large-diameter pipe set on the first stage of a well. One of its functions is to provide structural strength in order to hang the other casing strings

3.1.17**stress corrosion cracking****SCC**

cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) as defined in ISO 15156-1

Note 1 to entry: Parameters that influence the susceptibility to SCC are temperature, pH, chlorides, dissolved oxygen, H₂S and CO₂.

3.1.18**sulfide stress cracking****SSC**

cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H₂S as defined in ISO 15156-1

Note 1 to entry: SSC is a form of hydrogen stress cracking (HSC) and involves the embrittlement of the metal by atomic hydrogen that is produced by acid corrosion on the metal surface. Hydrogen uptake is promoted in the presence of sulfides. The atomic hydrogen can diffuse into the metal, reduce ductility and increase susceptibility to cracking. High strength metallic materials and hard weld zones are prone to SSC.

3.1.19

tubing hangers

device that supports a tubing string in the wellhead at the mudline

3.1.20

tubing string

a set of pipes placed in a well to produce or inject fluids

3.1.21

wireline

a general term used to describe well-intervention operations conducted using single-strand or multistrand wire or cable for intervention in oil or gas wells

3.2 Abbreviated terms

CCS carbon capture and storage

CRA corrosion-resistant alloy

EOR enhanced oil recovery

FFKM perfluorelastomer

FKM fluorelastomer

GRE glass-reinforced epoxy

HNBR hydrogenated nitrile butadiene rubber

ID internal diameter

PREN pitting resistance equivalent number

PA polyamide

PCTFE polychlorotrifluoroethylene

PEEK polyether ether ketone

PP polypropylene

PTFE polytetrafluoroethylene

PVDF polyvinylidene fluoride

RGD rapid gas decompression

pH₂S H₂S partial pressure

pCO₂ CO₂ partial pressure

SCCO₂ supercritical state of CO₂

WAG water alternating gas

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