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Petroleum and natural gas industries — Materials selection for high content CO_2 for casing, tubing and downhole equipment

Industries du pétrole et du gaz naturel — Choix des matériaux une teneur élevée en CO_2 pour tubes de cuvelage et de production et équipements de fond

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

Introduction

This International Standard gives recommendations and guidelines for materials selection in oil and gas production wells, specifically for high CO_2 content gas injection and production systems, as well 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 International Standard are oil and gas production companies and engineering contractors. Material manufacturers and equipment suppliers can benefit from using this International Standard for their product development.

Carbon capture and storage (CCS) has been identified as an important technology for achieving a significant reduction in CO_2 emissions to the atmosphere.

Many of the technologies and practices that have been developed for CO_2 enhanced oil recovery (EOR) can have applicability in CCS projects, assuming that each project design meets its site-specific conditions. The CO_2 EOR experiences of the oil and gas industry represent the largest collective base of technical information available on CO_2 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 can 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 (all parts) for H_2S containing service.

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

Petroleum and natural gas industries — Materials selection for high content CO_2 for casing, tubing and downhole equipment

1 Scope

This International Standard provides guidelines and requirements for material selection of both seamless casing and tubing, and downhole equipment for CO_2 gas injection and gas production wells with high pressure and high CO_2 content environments [higher than 10 % (molar) of CO_2 and 1 MPa CO_2 partial pressure]. Oil production wells are not covered in this International Standard. This International Standard only considers materials compatibility with the environment.

Guidance is given for the following:

— corrosion evaluation;

— materials selection;

— corrosion control.

This International Standard is aimed at high CO_2 content wells, where the threat of low pH and CO_2 corrosion is greatest. However, many aspects are equally applicable to environments containing lower CO_2 concentrations.

Materials selection is influenced by many factors and synergies and should be performed by either materials or corrosion engineer.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 abbreviated terms

3.1 Terms and definitions

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

3.1.1
A-annulus
designation of annulus between the production tubing and *production casing* (3.1.12)

[SOURCE: ISO/TS 16530-2:2014, 3.1]

3.1.2
casing
pipe run from the surface and intended to line the walls of a drilled well

[SOURCE: ISO 11960:2014, 4.1.5]

3.1.3
clad
cladding
metallurgically-bonded *CRA* (3.1.4) layer produced by roll bonding, weld overlaying, powder metallurgy or explosively cladding a carbon steel plate or pipe

[SOURCE: API 5LD 2009, 3.1.2]

3.1.4
corrosion-resistant alloy
CRA
alloy intended to be resistant to general and localized corrosion by oilfield environments that are corrosive to carbon steels

[SOURCE: ISO 15156-1:2015, 3.6]

3.1.5
cross-over
short subassembly that connects two different end connections

3.1.6
dense phase
fluid state (supercritical or liquid) above critical pressure

3.1.7
dry gas
gas operating at temperature at least 10 °C above water dew point at given pressure

Note 1 to entry: See ISO 21457:2010, 6.2.3.5.

3.1.8
gas production well
well 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)

3.1.9
intermediate casing
string that is set between the *surface casing* (3.1.19) and *production casing* (3.1.12)

Note 1 to entry: There may be more than one intermediate casing, enabling getting deeper in the well.

3.1.10
packer
mechanical device with a packing element, 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

[SOURCE: ISO 14310:2008, 3.26]

3.1.11
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 the following formula:

$$PREN = wCr + 3{,}3\,(wMo + 0{,}5wW) + 16wN$$

where

wCr is the weight percentage of chromium in the alloy;

wMo is the weight percentage of molybdenum in the alloy;

wW is the weight percentage of tungsten in the alloy;

wN is the weight percentage of nitrogen in the alloy

[SOURCE: ISO 21457:2010, 3.1.18, modified.]

3.1.12
production casing
pipe run from the surface and intended to line the walls of a drilled well, isolating production zone and/or injection zone

3.1.13
production packer
packer (3.1.10) used to isolate the *A-annulus* (3.1.1), blocking fluid communication by sealing on the ID of the *production casing* (3.1.12)

3.1.14
pup joint
casing (3.1.2) or tubing of length shorter than Range 1

[SOURCE: ISO 11960:2014, 4.1.37, modified — Note 1 to entry left out here.]

3.1.15
rapid gas decompression
RGD
depressurization
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

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.

[SOURCE: ISO 23936-2:2011, 3.1.10]

3.1.16
shoe
assembly screwed to the casing with a rounded profile, in order to guide the casing string throughout the wellbore

3.1.17
slickline
thin nonelectric cable used for selective placement and retrieval of wellbore hardware, such as plugs, gauges and valves located in sidepocket mandrels

3.1.18
supercritical state
fluid state above critical pressure and temperature

3.1.19
surface casing
large-diameter pipe set on the first stage of a well

Note 1 to entry: One of its functions is to provide structural strength in order to hang the other casing strings.

3.1.20
stress corrosion cracking
SCC
cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) in the presence of water and H_2S

Note 1 to entry: Parameters that influence the susceptibility to SCC are temperature, pH, chlorides, oxidants, H_2S and CO_2.

[SOURCE: ISO 15156-1:2015, 3.21, modified — changed set of parameters in Note 1 to entry.]

3.1.21
sulfide stress cracking
SSC
cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H_2S

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.

[SOURCE: ISO 15156-1:2015, 3.23]

3.1.22
tubing hanger
device that supports a *tubing string* (3.1.23) in the wellhead at the mudline

3.1.23
tubing string
set of pipes placed in a well to produce or inject fluids

3.1.24
wireline
one type of equipment and associated technique(s) used to perform various operations in a well using a continuous length of solid line (slick line) or stranded wire, appropriate spooling equipment at the surface and weight stem and specialized tools attached to the well (downhole) end of the wire

[SOURCE: ISO 17078-1:2004, 3.50]

3.2 Abbreviated terms

CCS carbon capture and storage

CRA corrosion resistant alloy

EOR enhanced oil recovery

FEPM copolymer of tetrafluoroethylene and propylene

FFKM perfluorelastomer

FKM fluorelastomer

GRE glass reinforced epoxy

HNBR hydrogenated nitrile butadiene rubber

ID internal diameter

PREN pitting resistance equivalent number

PA polyamide

PCTFE polychlorotrifluorethylene

PEEK polyether ether ketone

PP polypropylene

PTFE polytetrafluorethylene

PVDF polyvinylidene fluoride

RGD rapid gas decompression

pH_2S H_2S partial pressure

pCO2 CO_2 partial pressure

SCCO2 supercritical state of CO_2

TFE/P copolymer of tetrafluoroethylene and propylene

WAG water alternating gas

4 Guidelines for corrosion evaluation

4.1 General

The materials selection process shall take into account all statutory and regulatory requirements. The project design criteria, such as design lifetime, inspection and maintenance philosophy, type and frequency of interventions, safety and environmental profiles shall be considered.

In general, robust materials selection should be made to ensure operational reliability throughout the design life. For offshore installations, access for the purposes of maintenance and repair should be carefully considered in the design.