

CO₂ corrosion rate calculation model

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Introduction

This NORSOK standard, which is a recommended practice, contains

- a computer program for corrosion rate calculations which is available for downloading free of charge from the NORSOK internet website (<http://www.standard.no>) or can be procured from Standards Norway,
- a user manual for the computer program. A description of the calculation model, the algorithms and the conditions for the corrosion rate calculations are given. In additions, methods and algorithms for calculation of essential input parameters to the corrosion rate calculations are given.

1 Scope

This NORSOK standard presents a recommended practice for calculation of corrosion rates in hydrocarbon production and process systems where the corrosive agent is CO₂.

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

2.1 Normative references

NORSOK M-001, Materials selection

2.2 Informative references

None

3 Terms, definitions and symbols

For the purposes of this NORSOK standard, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1

can

verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.2

may

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.3

shall

verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.4

should

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.2 Symbols

A	is the cross sectional area in m ²
$B_{(index)}$	is the constant used in viscosity calculations
$C_{(index)}$	is the concentration of component
CR _t	is the corrosion rate at temperature t in mm/year
D	is the pipe diameter in mm
F _{H₂O}	is the water mass flow in humidity calculations
F _{tot}	is the total mass flow in humidity calculations
$K_{(index)}$	is the equilibrium constant used in pH calculations
K _{SP}	is the equilibrium constant of iron carbonate
K _t	is the constant for the temperature t used in corrosion rate calculations
P	is the total system pressure in bar
Q _G	is the volumetric flow of gas in MSm ³ /d
Q _L	is the volumetric flow of liquid (i.e. liquid hydrocarbons and water) in Sm ³ /d
R	is μ_w/μ_o

Re	is the Reynolds number
S	is the wall shear stress in Pa
T	is the temperature given in Kelvin.
T_c	is the temperature given in °C
T_f	is the temperature given in °F
T_{std}	is the temperature given in Kelvin at standard conditions (60 °F/15,55 °C)
Z	is the compressibility of the gas
a	is the fugacity coefficient
f	is the friction factor
f_{CO_2}	is the fugacity of CO ₂ in bar
$f(pH)_t$	is the the pH factor at temperature t
k	is the pipe roughness in m
I	is the ionic strength given in molar
p_{CO_2}	is the CO ₂ partial pressure in bar
p_{H_2O}	is the H ₂ O vapour pressure in bar
t	is the 20 °C, 40 °C, 60 °C, 80 °C, 90 °C, 120 °C or 150 °C
u_G^S	is the superficial velocities of gas in m/s
u_L^S	is the superficial velocities of liquid in m/s
u_m	is the mixed velocity (m/s)
λ	is the liquid fraction
μ_o	is the viscosity of oil in Ns/m ²
μ_G	is the viscosity of gas in Ns/m ²
μ_L	is the viscosity of liquid in Ns/m ²
μ_m	is the mixed viscosity in Ns/m ²
μ_{relmax}	is the maximum relative viscosity (relative to the oil)
μ_w	is the viscosity of water in Ns/m ²
ρ_G	is the gas density in kg/m ³
ρ_L	is the liquid density in kg/m ³
ρ_m	is the mixed density in kg/m ³
ρ_o	is the oil density in kg/m ³
ρ_w	is the water density kg/m ³
ϕ	is the watercut
ϕ_c	is the watercut at inversion point

4 Principles for use of the computer program

The corrosion rate equations included in this NORSOK standard describe the calculation model which shall apply, while the computer program itself is an optional aid which the users of the model may apply such that they possess an efficient tool to conduct corrosion rate calculations and parameter studies. This computer program is developed based on the corrosion rate model given as equations in this NORSOK standard.

The computer program is an aid in CO₂ corrosion rate assessments, but the user of the computer program is responsible for the results and the final material selections and piping and equipment design. Therefore the user of the program shall perform a critical evaluation of all results and the applicability of these in each case. Corrosion rate calculation, is only one element in a material selection process. Other essential factors are uncertainty in input data for corrosion rate calculations, construction and commissioning conditions, consideration of normal and upset operating conditions, actual corrosivity of produced fluids, scale, wax, inhibitor efficiency and geometry of corrosion attacks. These and other factors may influence the actual corrosion rates considerably, and be more important than any uncertainty in the corrosion rate calculations.

As the computer program is distributed electronically and may be used on different computers and computer program versions, users of the computer program are sole responsible to verify that the computer calculations are in accordance with the equations in this NORSOK standard.

This NORSOK standard provides an introduction to the corrosion rate computer program. It also gives limitations and requirements to input parameters and results. Instructions for running the program are given in the help functions to the program.