

NORSOK STANDARD

CO₂ CORROSION RATE CALCULATION MODEL

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and eliminate unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. by replacing individual oil company specifications and other industry guidelines and documents for use in existing and future petroleum industry developments.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, the NORSOK standard will be withdrawn.

The computer program is informative.

INTRODUCTION

This standard contains two parts as described below:

1. The Clauses 4, 5, 6, 7 and 8 in this standard acts as the 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.
2. The computer program for corrosion rate calculations is available for downloading free of charge from the NTS/NORSOK Internet website (<http://www.nts.no/norsok>) or it may be procured from NTS, Oslo.

1 SCOPE

The scope of this standard is to present a method for calculation of corrosion rates in hydrocarbon production and process systems where the corrosive agent is CO₂.

The standard has primarily been developed for calculation of corrosion rates in topside piping systems and vessels, but the program may also be used for calculation of corrosion rates in pipeline systems and subsea production facilities.

2 NORMATIVE REFERENCES

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

NORSOK standard M-001 "Material Selection".

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

Can	Verbal form used for statements of possibility and capability, whether material, physical or casual.
Informative references	Shall mean informative in the application of NORSOK standards.
May	Verbal form used to indicate a course of action permissible within the limits of the standard.
Shall	Verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties.
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	- cross sectional area (m ²)
a	- fugacity coefficient
CR _t	- corrosion rate at temperature t (mm/y)
C _(index)	- concentration of component
D	- pipe diameter
F _{H2O}	- water mass flow in humidity calculations
F _{tot}	- total mass flow in humidity calculations
f	- friction factor

$f(\text{pH})_t$	- the pH factor at temperature t
f_{CO_2}	- fugacity of CO ₂ (bar)
ϕ	- watercut
ϕ_c	- watercut at inversion point
I	- ionic strength given in molar.
k	- pipe roughness (m)
$K_{(\text{index})}$	- equilibrium constant used in pH calculations
$K_{(\text{index})}$	- constant used in viscosity calculations
K_t	- constant for the temperature t used in corrosion rate calculations
λ	- liquid fraction
μ_o	- viscosity of oil (Ns/m ²)
μ_G	- viscosity of gas (Ns/m ²)
μ_L	- viscosity of liquid (Ns/m ²)
μ_m	- mixed viscosity (Ns/m ²)
μ_{relmax}	- maximum relative viscosity (relative to the oil)
μ_w	- viscosity of water (Ns/m ²)
P	- total system pressure (bar)
p_{CO_2}	- CO ₂ partial pressure (bar)
$p_{\text{H}_2\text{O}}$	- H ₂ O vapour pressure
Q_G	- volumetric flow of gas (MSm ³ /d)
Q_L	- volumetric flow of liquid, i.e. liquid hydrocarbons and water, (Sm ³ /d)
Re	- Reynolds number
ρ_G	- gas density (kg/m ³)
ρ_L	- liquid density (kg/m ³)
ρ_m	- mixed density (kg/m ³)
ρ_o	- oil density (kg/m ³)
ρ_w	- water density (kg/m ³)
S	- wall shear stress (Pa)
t	- 20, 40, 60, 80, 90, 120 or 150°C
T_c	- temperature given in °C
T_f	- temperature given in °F
T	- temperature given in Kelvin.
T_{std}	- temperature given in Kelvin at standard conditions (60 °F/15,55 °C)
u_m	- mixed velocity (m/s)
u_G^S	- superficial velocities of gas (m/s)
u_L^S	- superficial velocities of liquid (m/s)

4 PRINCIPLES FOR USE OF THE COMPUTER PROGRAM

The corrosion rate equations included in this 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 standard.