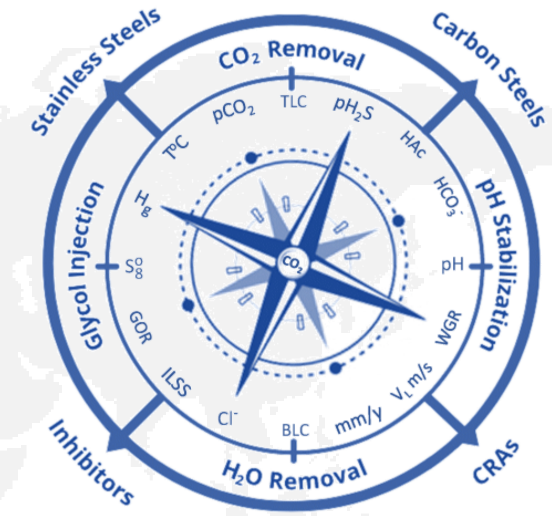


Corrosion Modeling Software and Corrosion Prediction Software Series

CO2Compass®: CO2 Corrosion Prediction, Modeling, Assessment, and Solutions

The Ultimate Predictive Software Solution to Costly CO2 Corrosion

Version 9.22

★ **Performance** ★ **Functionality** ★ **Usability**

Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plug-ins

Contact Us for Licensing Details

Why WebCorr | Performance Guarantee | Unparalleled Functionality | Unmatched Usability | Any Device Any OS | Free Training & Support | CorrCompass

CO2Compass is the next generation predictive software for CO2 corrosion prediction and CO2 corrosion modeling. Unique features of CO2Compass not found in any other commercially available CO2 prediction software:

1. Performance Guarantee

WebCorr is the only corrosion software developer who offers you a performance guarantee. We stand behind the accuracy of our corrosion software. If at any time during the license period, the corrosion rates predicted by WebCorr's corrosion prediction software and corrosion modeling software are not closer to the measured values than the values predicted by any other corrosion prediction and corrosion modeling software on the market, we will refund the pro-rated license fee to you. It is that simple. No other corrosion prediction software and corrosion modeling software developer offers you this performance guarantee.

CO2Compass models the effects of liquid velocity, dissolved oxygen, bicarbonate, NaCl, H2S, HAc, elemental sulfur, and elemental mercury on CO2 corrosion with unmatched accuracy across the entire operating parameter values. Validate your existing CO2 corrosion modeling software and CO2Compass using the recommended CO2 corrosion model validation matrix and see for yourself the striking performance difference.

2. Unparalleled Functionality

Practical Solutions: Traditional CO2 corrosion prediction and CO2 corrosion modeling software are limited in their capability to the prediction of the corrosion rate only, without due consideration to the CO2 corrosion control strategy under the prevailing operating conditions of a pipeline or production tubing. CO2Compass, the next generation CO2 corrosion prediction and corrosion modeling software goes far beyond the prediction of the corrosion rate – it utilizes machine learning and cloud computing to optimize a particular CO2 corrosion control strategy with specific and quantitative control targets under the prevailing operating conditions of a pipeline or production tubing. Significant cost savings can be realized for asset owners at both the design and operation phases of pipelines or production tubing. CO2Compass is not just for CO2 corrosion prediction, it also provides users with expert guidance on practical solutions for mitigating CO2 corrosion. Based on the predicted CO2 corrosion rate, the prevailing operating conditions, the flow regimes, and the water analysis results, CO2Compass makes an overall assessment of the complete system and generates recommendations for CO2 corrosion mitigation strategies and precise control targets for CO2 Removal, Glycol Injection, pH Stabilization, and Water Removal:

- Corrosion and Erosion Risks
- Elemental Sulfur Corrosion Risk
- Mercury Risk and Liquid Metal Embrittlement Risk
- Inhibitor Risk Categories and Inhibitor Likelihood Success Score (ILSS)
- SSC and HIC Susceptibility (NACE MR 175/ISO-15156: 2020)
- CO2 Corrosion Mitigation Strategies and Control Targets for CO2 Removal, Glycol Injection, pH Stabilization, and Water Removal)
- Material Selection Options (Carbon Steels, 316 SS, Duplex SS & CRAs)

The screenshot below shows that the risk of elemental sulfur corrosion is high, with an increase in corrosion rate of 780.09% under the prevailing operating conditions when elemental sulfur is present. No other CO2 corrosion modeling software offers this function.

Corrosion/Erosion Risk, Elemental Sulfur/Mercury Risk, Inhibitor Effectiveness & Risk Categories and Guidelines		
Corrosion Risk Category	Medium	System will only reach 25% of its design life if no action is taken.
Corrosion Dominating Process	S Corrosion	Free sulfur may cause catastrophic failure, with pitting rate up to 30 mm/y.
Erosion Corrosion Risk	Low	Within API erosional velocity limit. Erosion corrosion is unlikely.
Elemental S Corrosion Risk	High	The corrosion rate in the presence of elemental sulfur is increased by 780.09%.
Mercury Risk Category	No Risk	No mercury is present in the system. No LME or health/safety issue.
Inhibition Effectiveness (ILSS)	1.31	Corrosion inhibition will be successful.
Inhibitor Risk Category (1~4)	1	Typical concentrations of 50 ppm may be expected.

SSC and HIC Susceptibility (ISO 15156/NACE MR0175: 2015)	
Region 0: No SSC SSC-resistant steels are not required	HIC: HIC is not likely to occur. HIC-resistant steels are not required.

Corrosion Mitigation Strategies and Control Targets to Meet the Design Life			
CO_2 Removal	Glycol Injection	pH Stabilization	Water Removal
Max. pCO2 (bar) allowed:	Min. concentration required:	feasible, target pH:	feasible
0.3550	31.83%	5.65	Max. H2O in HC liquid, and
Max. CO2 %mol allowed:	Min. injection (kg/MMm3 gas):	Bicarbonate required (ppm):	in gas (kg/MMm3):
0.7100	491	530	99

Material Selection Options	
Carbon steel can be used with any of the control options above, or when the CA (mm) is increased to:	7.06
AISI 316 stainless steel may be considered.	
Duplex stainless steels and other CRAs may be considered.	

The risks of mercury on liquid metal embrittlement (LME), health and safety are also assessed by CO2Compass. The following screenshot shows that the mercury risk is high with liquid metal embrittlement being highly likely and detailed speciation, frequent monitoring and stringent controls are required to address the health and safety concerns. No other CO2 corrosion modeling software offers this function.

Corrosion/Erosion Risk, Elemental Sulfur/Mercury Risk, Inhibitor Effectiveness & Risk Categories and Guidelines		
Corrosion Risk Category	Medium	System will only reach 25% of its design life if no action is taken.
Corrosion Dominating Process	CO2 Corrosion	With formation of FeCO3 scale, pitting is unlikely.
Erosion Corrosion Risk	Low	Within API erosional velocity limit. Erosion corrosion is unlikely.
Elemental S Corrosion Risk	No Risk	No elemental sulfur is present. Corrosion rate is not affected.
Mercury Risk Category	High	LME highly likely. Detailed speciation, frequent monitoring & stringent controls are required.
Inhibition Effectiveness (ILSS)	0.88	Corrosion inhibition will be successful.
Inhibitor Risk Category (1~4)	1	Typical concentrations of 50 ppm may be expected.

SSC and HIC Susceptibility (ISO 15156/NACE MR0175: 2015)	
Region 0: No SSC	HIC: HIC is not likely to occur.
SSC-resistant steels are not required	HIC-resistant steels are not required.

Corrosion Mitigation Strategies and Control Targets to Meet the Design Life			
CO_2 Removal	Glycol Injection	pH Stabilization	Water Removal
Max. pCO2 (bar) allowed:	Min. concentration required:	feasible, target pH:	feasible
0.4000	31.83%	5.65	Max. H2O in HC liquid, and
Max. CO2 %mol allowed:	Min. injection (kg/MMm3 gas):	Bicarbonate required (ppm):	in gas (kg/MMm3):
0.8000	491	340	99

Material Selection Options	
Carbon steel can be used with any of the control options above, or when the CA (mm) is increased to:	5.54
AISI 316 stainless steel may be considered.	
Duplex stainless steels and other CRAs may be considered.	

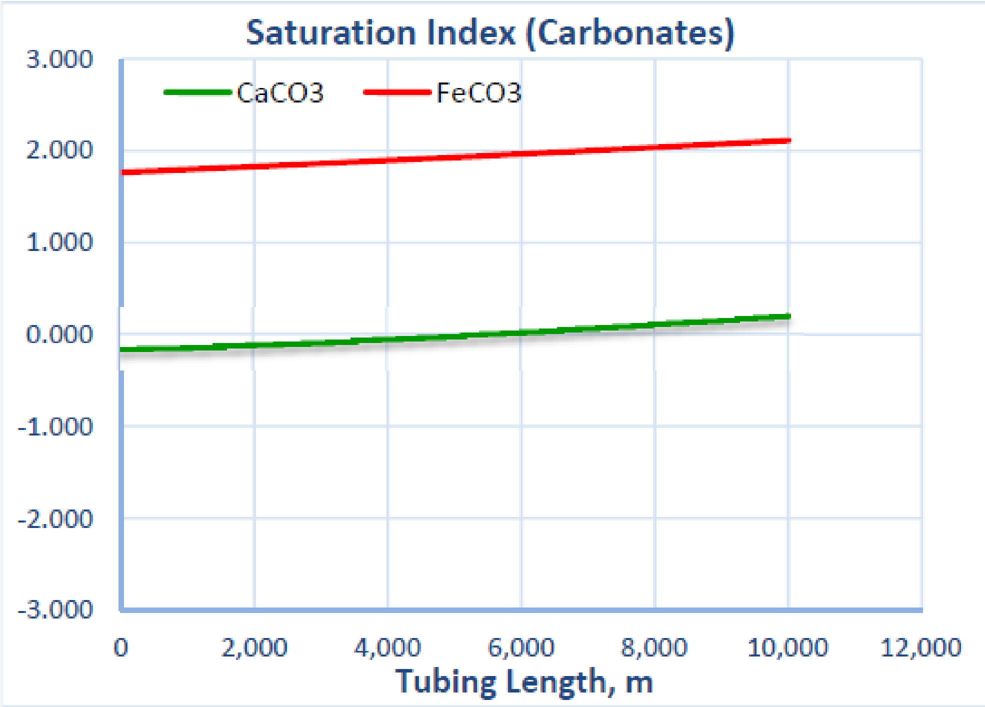
Under the Corrosion Control Options in CO2Compass, the critical levels of four major parameters (CO2 content, glycol concentration and injection rate, pH and bicarbonate dosage, and water content) that can **independently** reduce the predicted corrosion rate to meet the design value are all calculated automatically. CO2Compass gives the user effective and powerful tools to **assess** and **optimize** a particular CO2 corrosion mitigation strategy with precise control targets. For example, CO2 removal can be used alone or in combination with other options such as corrosion inhibition, glycol injection, and pH stabilization to reduce the predicted corrosion rate to a level that will meet the design requirement, thus extending the applicability of carbon steels to situations that might otherwise require the use of CRAs. No other CO2 corrosion prediction software offers this function. This unique feature alone can literally save asset owners millions of dollars. A real-life case study is presented in the 5-day course on "CO2 Corrosion Modeling for the Prediction of Internal Corrosion in Oil & Gas Pipelines and Production Tubing".

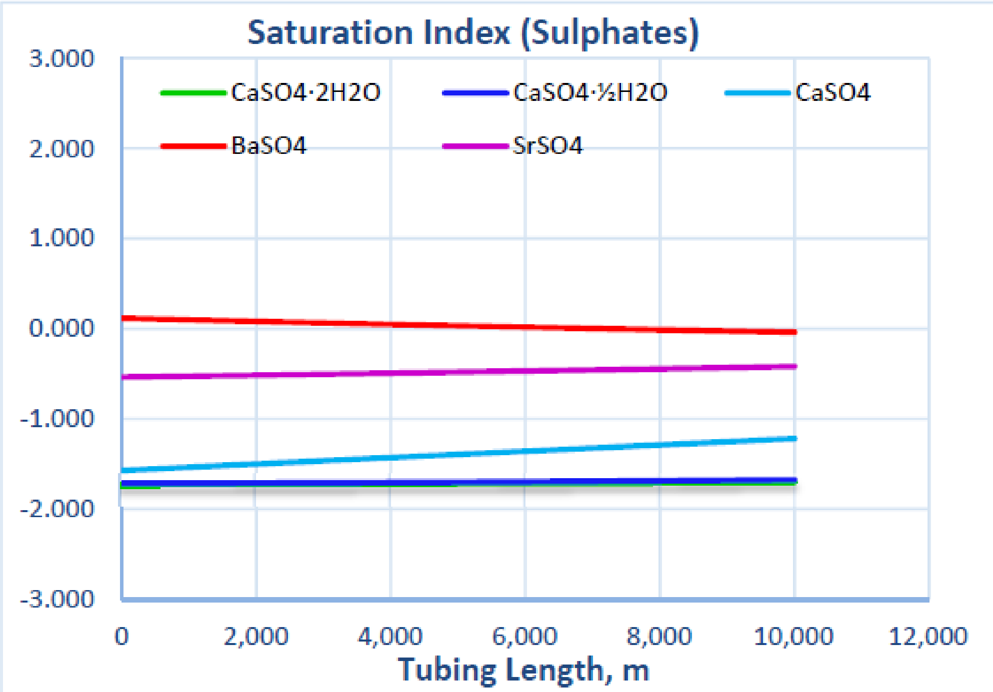
Scale Prediction:

CO2Compass has a built-in module for the prediction of scaling tendency. The seamless integration of the scale prediction engine into the rigorous thermodynamic framework for corrosion modeling makes CO2Compass a powerful tool in assessing and mitigating the risks of both corrosion and scaling at the same time and with minimal effort from the user. Saturation indices for scales commonly encountered in oil and gas production, processing and transmission are calculated automatically based on the prevailing operating conditions and water analysis results. No other CO2 corrosion modeling software offers this feature.

Scaling Tendency and Saturation Index

	Wellhead	Bottomhole	Change in SI (ΔSI)	Comments
Calcite (CaCO3)	-0.161	-0.002	-0.158	No scaling potential
Siderite (FeCO3)	1.766	2.126	-0.360	Scaling is likely to occur
Gypsum (CaSO4·2H2O)	-1.741	-1.738	-0.003	No scaling potential
Hemihydrate (CaSO4·½H2O)	-1.713	-1.714	0.001	No scaling potential
Anhydrite (CaSO4)	-1.570	-1.226	-0.344	No scaling potential
Barite (BaSO4)	0.117	-0.074	0.192	Scaling is unlikely to occur
Celestite (SrSO4)	-0.536	-0.442	-0.094	No scaling potential





In-situ pH Calculator:

An in-situ pH calculator allows the user to instantly determine the in-situ pH under the prevailing operating conditions (high temperature and pressure) from the water analysis conducted in the laboratory at ambient temperature and pressure. If the target in-situ pH for pH stabilization treatment is changed, the required concentration of [HCO3-] to meet the target in-situ pH is instantly calculated. The scaling tendency under pH stabilization treatment is updated dynamically in real-time, allowing the user to assess and mitigate the risks of both corrosion and scaling at the same time and with minimal effort. No other CO2 corrosion prediction software offers this feature.

Water Analysis

Produced water or Lab prepared solutions			No Fe Supersaturation at Inlet		
Iron, Fe2+	ppm	35.00	Bicarbonate, HCO_3^-	ppm	476.00
Calcium, Ca2+	ppm	270.00	All organic acids ($HAc+Ac^-$)	ppm	200.00
Magnesium, Mg2+	ppm	270.00	Chloride, Cl-	ppm	12,360.00
Sodium, Na+	ppm	7,469.00	Sulphate, SO_4^{2-}	ppm	260.00
Potassium, K+	ppm	0.00	Dissolved O_2	ppm	0.00
Barium, Ba2+	ppm	1.00	Total Dissolved Solids	ppm	21,379
Strontium, Sr2+	ppm	38.00	Ionic Strength	M	0.38560
Calculated in-situ pH	5.87	Target pH 5.65	Required HCO_3^-	ppm	0

3. Unmatched Usability: CO2Compass was designed with the user in mind. Experience the industry's first cross-platform and device-independent CO2 corrosion modeling and prediction application on your tablets, notebooks, and desktops, at any time and anywhere, in the office or in the field. No installation files to download, no browser plug-ins required, no USB dongles to carry around, and no license keys to transfer from one PC to another. **CO2Compass simply works on any device running any OS**. All you need is an internet browser. Unlike the black-box style of other CO2 corrosion modeling software, CO2Compass gives the user **complete** and **direct control** over the modeling of the effects of scaling, oil wetting, glycol, CO2 fugacity, in-situ pH, liquid velocity, organic acids, H2S, corrosion inhibitor availability, and inhibiting efficiency with **user-controlled ON/OFF switches** and direct inputs overriding the default settings. No other CO2 corrosion prediction and CO2 corrosion modeling software offers these powerful features.

Automatically generated and dynamically updated graphs are plotted in real-time as the user makes adjustments to the input parameters. These plots include corrosion rate profile, effect of temperature, effect of velocity, and effect of pH on the predicted CO2 corrosion rates.

Saturation indices of carbonates and sulphate scales are also plotted. A clean and concise report is automatically generated and dynamically updated in real-time as you enter or change the input parameters.

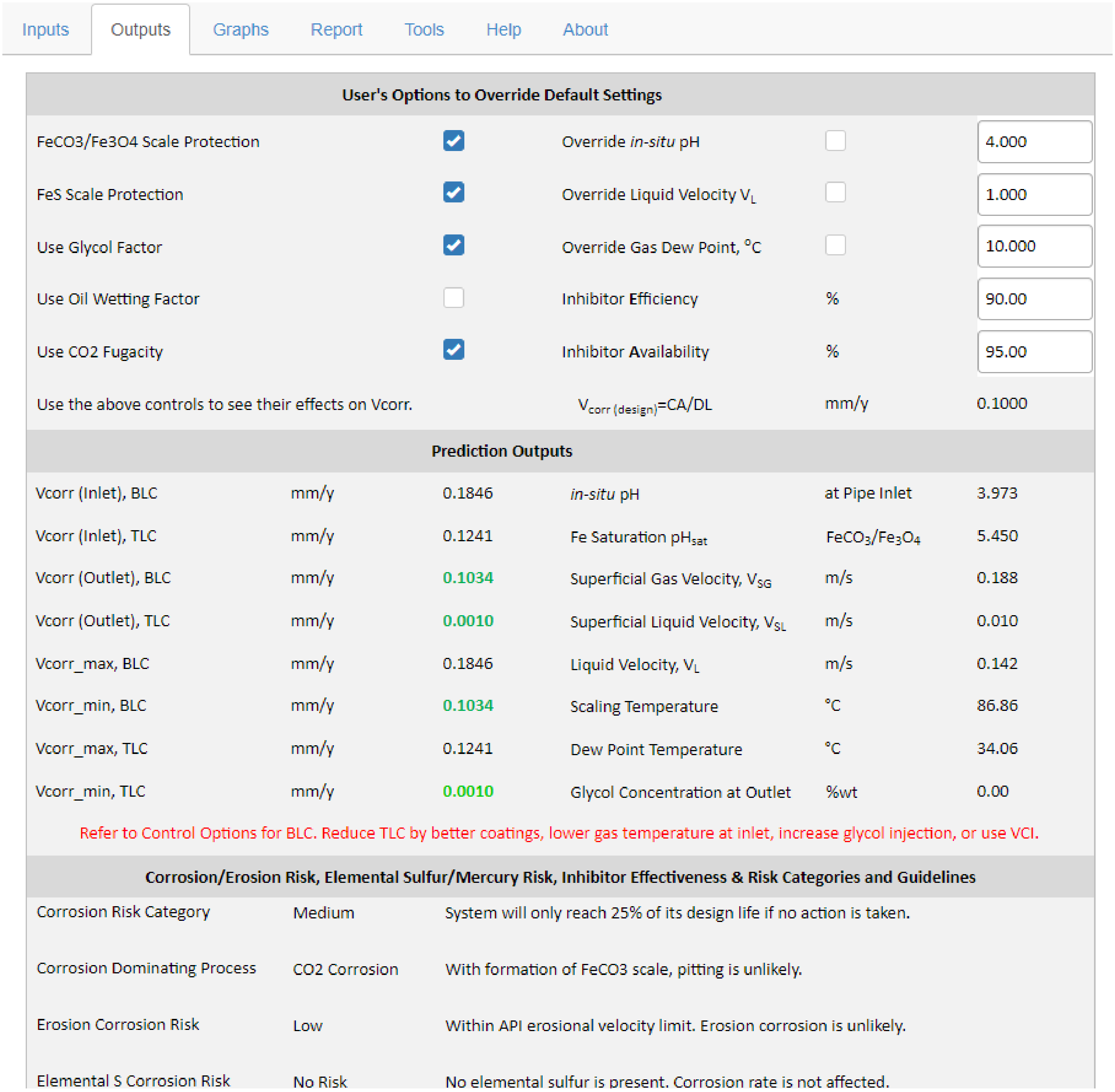
A Brief Overview of CO2Compass

Inputs | Outputs | Graphs | Report | Tools | Help | About

CO2Compass®: CO2 Corrosion Modeling, Prediction, Assessment & Solutions

Project Title					
Parameters in bold are the minimum inputs required.				Unit for Inputs Data:	Metric
Design Data					
Project Type	Pipeline	Horizontal	Predicted Vcorr_max,BLC	mm/y	0.1846
Angle of Inclination	deg	0.00	Predicted Vcorr_max,TLC	mm/y	0.1241
Pipe Length, PL	km	120.000	**Corrosion Allowance, CA**	mm	3.000
Pipe ID	m	0.3860	Pipe Wall Thickness	mm	10.0000
Pressure at Inlet	bar	50.00	**Design Life, DL**	yr	30.00
Pressure at Outlet	bar	40.00	Steel Microstructure		Default
Temperature at Inlet	°C	30.00	Cr Content	%Cr	0.08
Temperature at Outlet	°C	20.00	C Content	%C	0.18
Pipe Insulation at Inlet	4 mm 3LPP or 3LPE + 40 mm Concrete		Overall Heat Transfer Coefficient	W/(m2.K)	21.00
Water Analysis					
Produced water or Lab prepared solutions			No Fe Supersaturation at Inlet		
Iron, Fe2+	ppm	0.00	Bicarbonate, HCO_3^-	ppm	0.00
Calcium, Ca2+	ppm	0.00	All Organic Acids ($HAc+Ac^-$)	ppm	0.00
Magnesium, Mg2+	ppm	0.00	Dissolved O_2	ppm	0.00
Sodium, Na+	ppm	0.00	Total Dissolved Solids	ppm	0
Chloride, Cl^-	ppm	0.00	Ionic Strength	M	0.00000
Potassium, K+	ppm	0.00	Calculated in-situ pH	pH	3.97
Sulphate, SO_4^{2-}	ppm	0.00	pH Stabilization Target	pH	5.65
Barium, Ba2+	ppm	0.00	Required HCO_3^-	ppm	340
Strontium, Sr2+	ppm	0.00			
Flow Data					
Gas Flow Rate	MMSm3/d	0.1000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Oil/Condensate	m3/d	100.0000	Compressibility of Gas	0 ~ 1.0	0.900
Water at Inlet (m3/d)	total water	0.1000	Water Density	kg/m³	1024.000
CO_2 in Gas	%mol	2.0000	Oil/Condensate Density	kg/m³	780.000
H_2S in Gas	%mol	0.0000	API Oil Gravity	deg	50
Presence of Elemental Sulfur	free S^0_8	No	Partial Pressure pCO_2	bar	1.0000
Total Mercury in Liquid or Gas	(µg/m3 of gas)	0.00000	Partial Pressure pH_2S	bar	0.0000
Use Liquid Holdup Fraction	No	0.05000	pCO_2 to pH_2S Ratio	pCO_2/pH_2S	no H2S
Glycol Injection Rate	kg/d	0.000	Gas-to-Oil Ratio, GOR	m3/m3	1000.00
Glycol Conc. at Inlet	%wt	0.000	Water-to-Gas Ratio, WGR	m3/MMSm3	1.00
Watercut at Inlet	%	0.100	API Erosional Velocity Factor, C	(kg/m)^0.5/s	122
Watercut at Outlet	%	0.125	API Erosional Velocity Limit	m/s	22.95

CO2Compass has a clean and efficient user interface that instantly responds to changes in user inputs. You do not need to select the input parameter range before entering the input parameter value or wait for flashy and sluggish screens to update the displayed calculation results. In CO2Compass, all input parameters are presented under the Inputs Tab. All calculation results are presented under the Outputs Tab. Users have **complete control** over the modeling process by **directly overriding the default settings** for parameters such as in-situ pH, liquid velocity, FeCO3/Fe3O4 scale protection, FeS scale protection, oil wetting, glycol effect, CO2 fugacity, inhibitor efficiency and inhibitor availability. Refer to the image below for details.


Inputs | Outputs | Graphs | Report | Tools | Help | About

User's Options to Override Default Settings				
FeCO3/Fe3O4 Scale Protection	☑	Override *in-situ* pH	☐	4.000
FeS Scale Protection	☑	Override Liquid Velocity V_L	☐	1.000
Use Glycol Factor	☑	Override Gas Dew Point, °C	☐	10.000
Use Oil Wetting Factor	☐	Inhibitor Efficiency	%	90.00
Use CO2 Fugacity	☑	Inhibitor Availability	%	95.00
Use the above controls to see their effects on Vcorr.		$V_{corr\ (design)}$=CA/DL	mm/y	0.1000

Prediction Outputs					
Vcorr (Inlet), BLC	mm/y	0.1846	*in-situ* pH	at Pipe Inlet	3.973
Vcorr (Inlet), TLC	mm/y	0.1241	Fe Saturation pH_{sat}	$FeCO_3/Fe_3O_4$	5.450
Vcorr (Outlet), BLC	mm/y	0.1034	Superficial Gas Velocity, V_{SG}	m/s	0.188
Vcorr (Outlet), TLC	mm/y	0.0010	Superficial Liquid Velocity, V_{SL}	m/s	0.010
Vcorr_max, BLC	mm/y	0.1846	Liquid Velocity, V_L	m/s	0.142
Vcorr_min, BLC	mm/y	0.1034	Scaling Temperature	°C	86.86
Vcorr_max, TLC	mm/y	0.1241	Dew Point Temperature	°C	34.06
Vcorr_min, TLC	mm/y	0.0010	Glycol Concentration at Outlet	%wt	0.00

Refer to Control Options for BLC. Reduce TLC by better coatings, lower gas temperature at inlet, increase glycol injection, or use VCI.

Corrosion/Erosion Risk, Elemental Sulfur/Mercury Risk, Inhibitor Effectiveness & Risk Categories and Guidelines		
Corrosion Risk Category	Medium	System will only reach 25% of its design life if no action is taken.
Corrosion Dominating Process	CO2 Corrosion	With formation of FeCO3 scale, pitting is unlikely.
Erosion Corrosion Risk	Low	Within API erosional velocity limit. Erosion corrosion is unlikely.
Elemental S Corrosion Risk	No Risk	No elemental sulfur is present. Corrosion rate is not affected.

Mercury Risk Category	No Risk	No mercury is present in the system. No LME or health/safety issue.
Inhibition Effectiveness (ILSS)	0.88	Corrosion inhibition will be successful.
Inhibitor Risk Category (1~4)	1	Typical concentrations of 50 ppm may be expected.

SSC and HIC Susceptibility (BS EN ISO 15156: 2020)	
Region 0: No SSC	HIC: HIC is not likely to occur.
SSC-resistant steels are not required	HIC-resistant steels are not required.

Corrosion Mitigation Strategies and Control Targets to Meet the Design Life			
CO_2 Removal	Glycol Injection	pH Stabilization	Water Removal
Max. pCO2 (bar) allowed:	Min. concentration required:	feasible, target pH:	feasible
0.4000	31.83%	5.65	Max. H2O in HC liquid, and
Max. CO2 %mol allowed:	Min. injection (kg/MMm3 gas):	Bicarbonate required (ppm):	in gas (kg/MMm3):
0.8000	491	340	99

Material Selection Options	
Carbon steel can be used with any of the control options above, or when the CA (mm) is increased to:	5.54
AISI 316 stainless steel may be considered.	
Duplex stainless steels and other CRAs may be considered.	

Scaling Tendency and Saturation Index				
	Inlet	Outlet	Change in SI (ΔSI)	Comments
Calcite (CaCO3)	0.000	0.000	0.000	No scaling potential
Siderite (FeCO3)	0.000	0.000	0.000	No scaling potential
Gypsum (CaSO4·2H2O)	0.000	0.000	0.000	No scaling potential
Hemihydrate (CaSO4·½H2O)	0.000	0.000	0.000	No scaling potential
Anhydrite (CaSO4)	0.000	0.000	0.000	No scaling potential
Barite (BaSO4)	0.000	0.000	0.000	No scaling potential
Celestite (SrSO4)	0.000	0.000	0.000	No scaling potential

Unique features in CO2Compass not found in any other commercial CO2 prediction and CO2 corrosion modeling software include:

The Corrosion Risk Category, the Corrosion Dominating Process, the Elemental Sulfur Corrosion Risk, the Mercury Risk including the likelihood of liquid metal embrittlement (LME), the Inhibitor Effectiveness, measured by the Inhibitor Likelihood Success Score (ILSS), the Inhibitor Risk Category and typical inhibitor dosage are automatically generated as outputs.

Under the "Corrosion Control Options", the critical levels of pCO2, glycol, pH and H2O that can reduce the corrosion rate independently to meet the design requirement are calculated automatically based on the prevailing conditions. Users have the option to use the ON/OFF switches and adjust the input parameters to optimize a particular CO2 corrosion mitigation strategy. For example, glycol injection and pH stabilization can be optimized to permit the use of carbon steels in situations where CRAs may have to be considered. Refer to the image above for details. In this particular case shown in the image above, the predicted CO2 corrosion rate with corrosion inhibitor at 90% efficiency and 95% availability is 0.18 mm/y, which is still above the design limit of 0.1 mm/y. CO2Compass makes an overall assessment of the situation and automatically generates CO2 corrosion control options available to the user:

(1) **CO2 removal** alone can be used to reduce the inhibited CO2 corrosion rate to the design limit. The maximum CO2 partial pressure allowed is 0.400 bar or the maximum concentration of CO2 allowed is 0.800%. Note that reducing the total system pressure will also lower the partial pressure of CO2;

(2) **glycol injection** alone can be used to reduce the inhibited CO2 corrosion rate to the design limit. The minimum concentration of glycol required is 31.83% or the minimum injection rate is 491 kg per MMSM3 gas;

(3) **pH stabilization** alone can be used to reduce the inhibited CO2 corrosion rate to the design limit. The minimum pH required is 5.65 and the minimum concentration of bicarbonate to achieve the required pH is 340 ppm;

(4) **water removal** alone can also be used to reduce the inhibited CO2 corrosion rate to the design limit. The maximum water content in both the gas phase and the liquid phase should not exceed 99 kg/MMSM3; each of the 4 options can independently reduce the inhibited corrosion rate to the design limit;

(5) under the Material Selection Options, CO2Compass calculated the **corrosion allowance (CA)** required for carbon steel (5.54 mm) if none of the 4 corrosion control options is used.

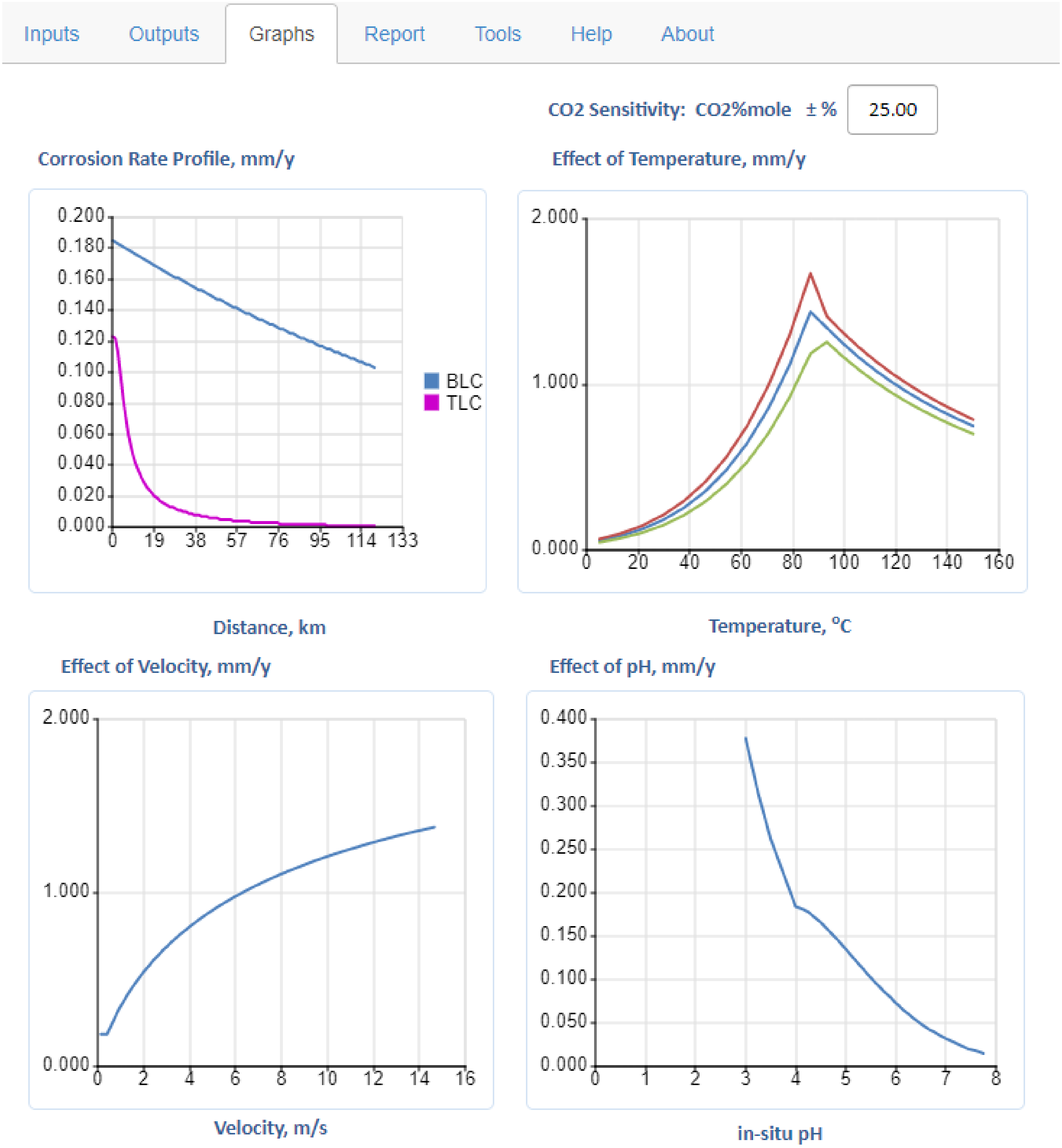
By varying the input parameters, users can optimize a particular CO2 corrosion control strategy with combined use of available options, thus extending the applicability of carbon steels to situations that might otherwise require the use of CRAs. This unique feature alone can literally save asset owners millions of dollars. A real-life case study is presented in the 5-day course on "CO2 Corrosion Modeling for the Prediction of Internal Corrosion in Oil & Gas Pipelines and Production Tubing".

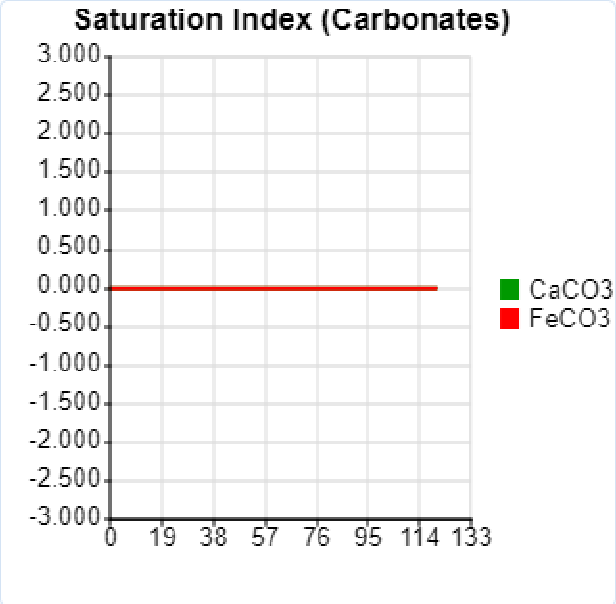
Under the Graphs Tab, automatically generated and dynamically updated graphs are plotted in real-time as the user makes adjustments to the input parameters. Users have instant access to the bigger pictures of CO2 corrosion under the prevailing operating conditions:

- the CO2 corrosion rate profile,
- the effect of temperature on the corrosion rate,
- CO2 sensitivity analysis,
- effect of velocity on CO2 corrosion rate,
- effect of pH on CO2 corrosion rate,
- scaling tendency: Saturation Index for carbonates scales,
- scaling tendency: Saturation Index for sulphates scales.

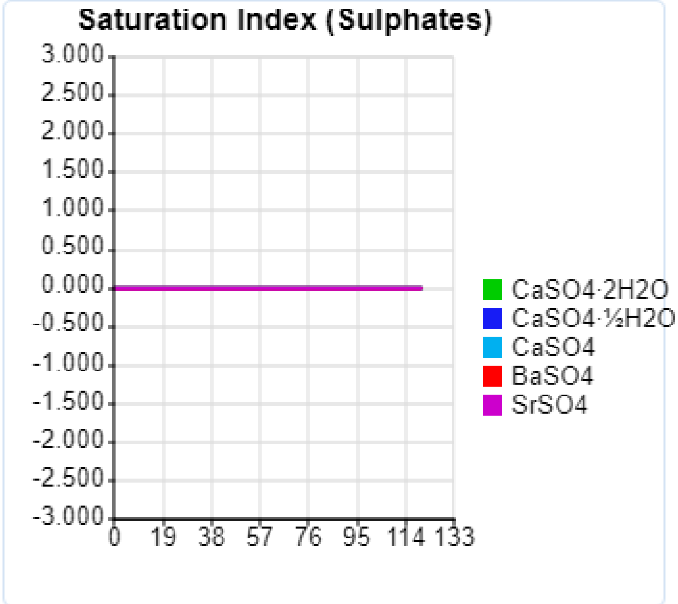
In the screenshot below, users can quickly and conveniently perform CO2 sensitivity analysis right under the Graphs Tab without going back to the Inputs screen. The top right corner has an input window where users can enter a percentage of the current CO2 content, CO2Compass plots two additional data sets, one for current CO2 content **minus** the entered percentage (the lower curve in the effect of temperature plot), and one for current CO2 content **plus** the entered percentage (the upper curve). For example, if the current prevailing CO2 content is 4% mole, and 25 (%) is entered into the window, CO2Compass plots the lower curve for 3% mole

(4-4x0.25=3) and upper curve for 5% mole (4+4x0.25=5). The resultant corrosion rates at 3%, 4%, and 5% CO2 are instantly displayed on the temperature plot. A quick glance at the plot will reveal the impact of the change in CO2 content on the corrosion rate. Users can make use of this feature to quickly assess the impact of off-spec gas on the corrosion risk of the pipelines and associated facilities, and more importantly to define an acceptable integrity operating window in terms of the plus/minus percentage of the current CO2 content under the prevailing operating conditions.





Distance, km



Distance, km

Under the report Tab, a clean and concise report is automatically generated and dynamically updated in real-time as you enter or change the input parameters.

Inputs | Outputs | Graphs | Report | Tools | Help | About

Project Title: XYZ Company's Wet Gas Pipeline CO2 Corrosion Prediction

CO2Compass ® Version 9.22 © WebCorr 1995-2022

Unit for Inputs Data: Metric

Design Data

Project Type	Pipeline	Horizontal		Predicted Vcorr_max,BLC	mm/y	0.1846
Angle of Inclination	deg	0.000		Predicted Vcorr_max,TLC	mm/y	0.1241
				Corrosion Allowance, CA	mm	3.000
Pipe Length, PL	km	120		Pipe Wall Thickness	mm	10.0000
Pipe ID	m	0.386		Design Life, DL	yr	30.00
		Inlet	Outlet		Microstructure	Default
Pressure at Outlet	bar	50.00	40.00		Chromium, Cr%	0.08
Temperature at Inlet	°C	30.00	20.00		Carbon, C%	0.18
Pipe Insulation at Inlet	4 mm 3LPP or 3LPE + 40 mm Concrete		Overall Heat Transfer Coefficient		W/(m2.K)	21.00

Water Analysis

Produced water or Lab prepared solutions — No Fe Supersaturation at Inlet

Iron, Fe^{2+}	ppm	0	Bicarbonate, HCO_3^-	ppm	0
Calcium, Ca^{2+}	ppm	0	All Organic Acids (HAc+Ac-)	ppm	0
Magnesium, Mg^{2+}	ppm	0	Chloride, Cl^-	ppm	0
Sodium, Na^+	ppm	0	Sulphate, SO_4^{2-}	ppm	0
Potassium, K^+	ppm	0	Dissolved O2	ppm	0
Barium, Ba^{2+}	ppm	0	Total Dissolved Solids	ppm	0
Strontium, Sr^{2+}	ppm	0	Ionic Strength	M	0.0000
3.97	3.97	Target pH: 5.65	Required HCO_3^-	ppm	340

Flow Data

Gas Flow Rate	MMSm3/d	0.1000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Oil/Condensate	m3/d	100.0000	Compressibility of Gas	0 ~ 1.0	0.900
Water at Inlet (m3/d)	total water	0.1000	Water Density	kg/m3	1024.000
CO2in Gas	%mol	2.0000	Oil/Condensate Density	kg/m3	780.000
H2S in Gas	%mol	0.0000	API Oil Gravity	deg	50
Presence of Elemental Sulfur	Free S	No	Partial Pressure pCO2	bar	1.0000
Total Mercury in Liquid or Gas	(µg/m3 of gas)	0.000	Partial Pressure pH2S	bar	0.0000
Use Liquid Holdup Fraction	No	0.05000	pCO2to pH2S Ratio	pCO2/pH2S	no H2S
Glycol Injection Rate	kg/d	0.000	Gas-to-Oil Ratio, GOR	m3/m3	1000.00
Water at Inlet (m3/d)	total water	0.1000	Water Density	kg/m3	1024.000
CO2in Gas	%mol	2.0000	Oil/Condensate Density	kg/m3	780.000
H2S in Gas	%mol	0.0000	API Oil Gravity	deg	50
Presence of Elemental Sulfur	Free S	No	Partial Pressure pCO2	bar	1.0000
Total Mercury in Liquid or Gas	(µg/m3 of gas)	0.000	Partial Pressure pH2S	bar	0.0000
Use Liquid Holdup Fraction	No	0.05000	pCO2to pH2S Ratio	pCO2/pH2S	no H2S
Glycol Injection Rate	kg/d	0.000	Gas-to-Oil Ratio, GOR	m3/m3	1000.00
Glycol Conc. at Inlet	%wt	0.000	Water-to-Gas Ratio, WGR	m3/MMSm3	1.00
Watercut at Inlet	%	0.100	API Erosional Velocity Factor, C	(kg/m)^0.5/s	122
Watercut at Outlet	%	0.125	API Erosional Velocity Limit	m/s	22.95

User's Options to Override Default Settings

FeCO3/Fe3O4 Scale Protection	Yes	Override *in-situ* actual pH	No	4.000

FeS Scale Protection	Yes	Override Liquid velocity V_L	No	1.000
Use Glycol Factor	Yes	Override Gas Dew Point, oC	No	10.000
Use Oil Wetting Factor	No	Inhibitor Efficiency	%	90.000
Use CO2 Fugacity	Yes	Inhibitor Availability	%	95.000
		Vcorr (design)=CA/DL	mm/y	0.100

Prediction Outputs

Vcorr (Inlet), BLC	mm/y	0.1846	in-situpH	at Pipe Inlet	3.973
Vcorr (Inlet), TLC	mm/y	0.1241	Fe Saturation pHsat	FeCO3/Fe3O4	5.450
Vcorr (Outlet), BLC	mm/y	0.1034	Superficial Gas Velocity, VSG	m/s	0.188
Vcorr (Outlet), TLC	mm/y	0.0010	Superficial Liquid Velocity, VSL	m/s	0.010
Vcorr_max, BLC	mm/y	0.1846	Liquid Velocity, VL	m/s	0.142
Vcorr_min, BLC	mm/y	0.1034	Scaling Temperature	°C	86.86
Vcorr_max, TLC	mm/y	0.1241	Dew Point Temperature	°C	34.06
Vcorr_min, TLC	mm/y	0.0010	Glycol Concentration at Outlet	%wt	0.000

Refer to Control Options for BLC. Reduce TLC by better coatings, lower gas temperature at inlet, increase glycol injection, or use VCI.

Corrosion/Erosion Risk, Elemental Sulfur/Mercury Risk, Inhibitor Effectiveness & Risk Categories and Guidelines

Corrosion Risk Category	Medium	System will only reach 25% of its design life if no action is taken.
Corrosion Dominating Process	CO2 Corrosion	With formation of FeCO3 scale, pitting is unlikely.
Erosion Corrosion Risk	Low	Within API erosional velocity limit. Erosion corrosion is unlikely.
Elemental S Corrosion Risk	No Risk	No elemental sulfur is present. Corrosion rate is not affected.
Mercury Risk Category	No Risk	No mercury is present in the system. No LME or health/safety issue.
Inhibition Effectiveness (ILSS)	0.88	Corrosion inhibition will be successful.
Inhibitor Risk Category (1~4)	1	Typical concentrations of 50 ppm may be expected.

SSC and HIC Susceptibility (BS EN ISO 15156: 2020)

Region 0: No SSC	HIC: HIC is not likely to occur.
SSC-resistant steels are not required	HIC-resistant steels are not required.

Corrosion Mitigation Strategies and Control Targets to Meet the Design Life

CO_2 Removal	Glycol Injection	pH Stabilization	Water Removal
Max. pCO2 (bar) allowed:	Min. concentration required:	feasible, target pH:	feasible
0.400	31.83%	5.65	Max. H2O in HC liquid, and
Max. CO2 %mol allowed:	Min. injection (kg/MMm3 gas):	Bicarbonate required (ppm):	in gas (kg/MMm3):
0.800	491	340	99

Material Selection Options

Carbon steel can be used with any of the control options above, or when the CA (mm) is increased to: 5.54

AISI 316 stainless steel may be considered.

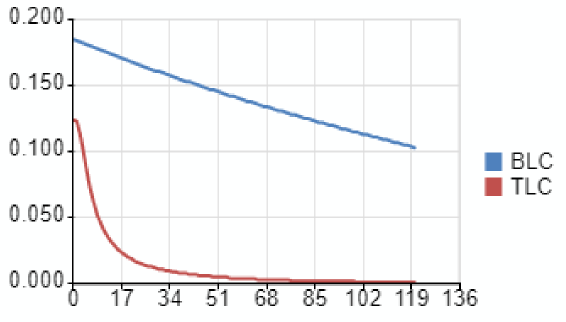
Duplex stainless steels and other CRAs may be considered.

Scaling Tendency and Saturation Index

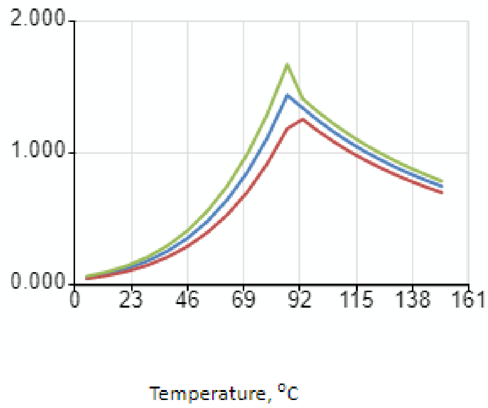
	Inlet	Outlet	Change in SI (ΔSI)	Comments
Calcite (CaCO3)	0.000	0.000	0.000	No scaling potential
Siderite (FeCO3)	0.000	0.000	0.000	No scaling potential
Gypsum (CaSO4·2H2O)	0.000	0.000	0.000	No scaling potential
Hemihydrate (CaSO4·½H2O)	0.000	0.000	0.000	No scaling potential
Anhydrite (CaSO4)	0.000	0.000	0.000	No scaling potential
Barite (BaSO4)	0.000	0.000	0.000	No scaling potential
Celestite (SrSO4)	0.000	0.000	0.000	No scaling potential

CO2 Sensitivity: CO2%mole ± % 25.00

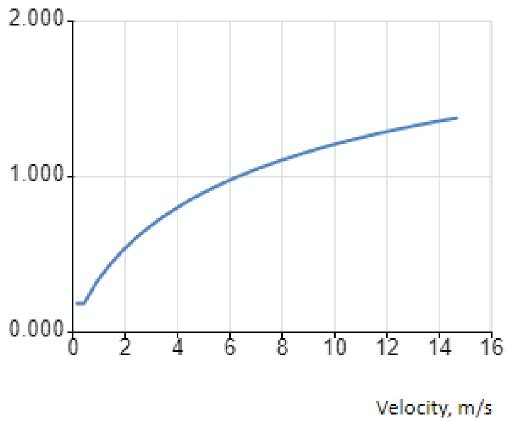
Corrosion Rate Profile, mm/y



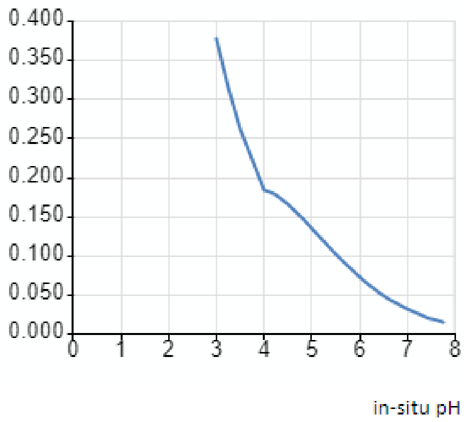
Effect of Temperature, mm/y

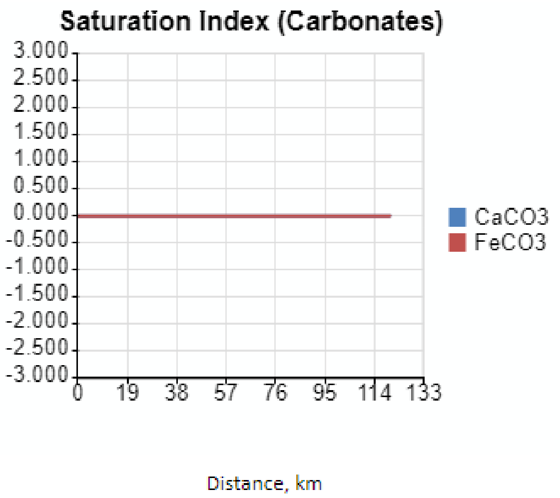


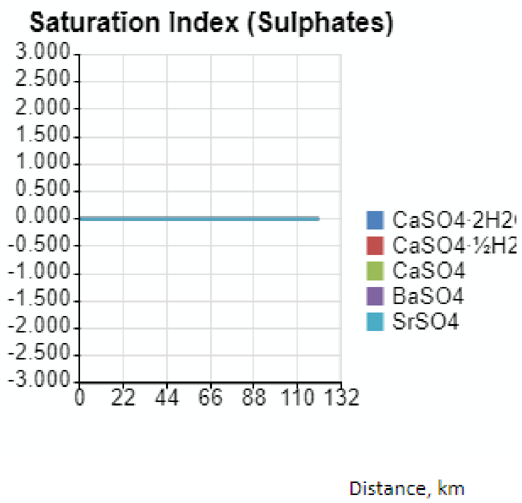
Effect of Velocity, mm/y



Effect of pH, mm/y







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