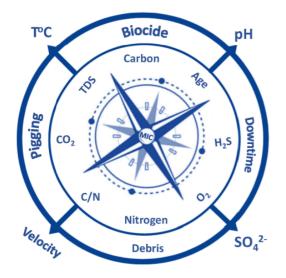


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Corrosion Modeling Software and Corrosion Prediction
Software Series

## MIC-Compass®: Modeling and Prediction of Microbiologically Influenced Corrosion in Oil and Gas Pipelines

High-Value Software Solutions to Costly Corrosion

Version 12.4





Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plugins

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

## **Overview of MIC-Compass**

MIC-Compass is the only device and OS independent software tool on the market for the prediction and modeling of microbiologically influenced corrosion (MIC) in oil and gas pipelines. Pipeline engineers, consultants, operation personnel, maintenance and inspection engineers can quickly assess the MIC risk, identify the dominating corrosion process in the pipeline (be it MIC or other types of corrosion such as CO2 corrosion, H2S corrosion, CO2-H2S mixed corrosion, and oxygen corrosion), and determine the corrosion rates under the prevailing

operating conditions. MIC-Compass works on any device running any OS without the need to install or download anything.

The presence of bacteria in the water/deposit samples collected from a pipeline does not necessarily mean that MIC will occur in the pipeline and the absence of bacteria in the water/deposit samples does not necessarily mean that MIC will not occur in the pipeline. There is no single factor that can trigger the initiation of MIC. The initiation and the growth rate of MIC are determined by a number of factors working in synergy:

- operating temperature
- in-situ pH
- liquid velocity
- oxygen content
- sulphate content
- total dissolved solids (TDS)
- total carbon from fatty acids
- nitrogen content
- biocide
- debris/deposit
- pigging frequency
- operation and maintenance

Figures below demonstrate the operation of MIC-Compass. MIC-Compass has a built-in *in-siu* pH calculator that determines the *in-situ* pH under the prevailing operating temperature and pressure. The pH reported from water analysis conducted by testing labs at room temperature and pressure is not the "*in-situ*" pH. It is the "*in-situ*" pH that matters in MIC and other types of corrosion such as CO2 corrosion in oil and gas pipelines.

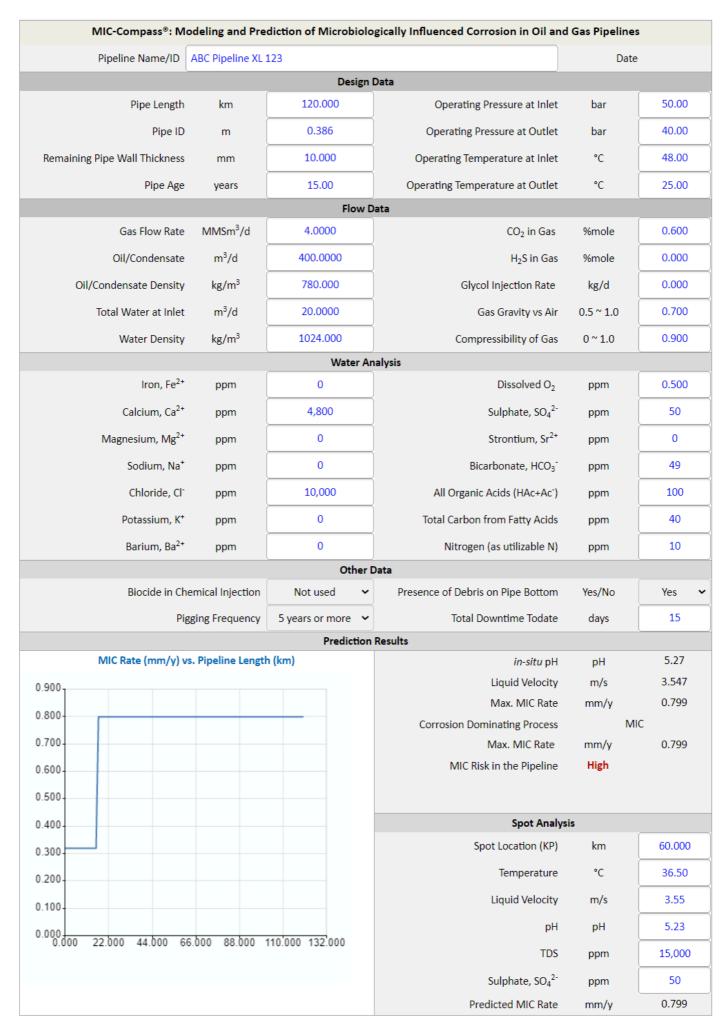


Figure 1 MIC-Compass Predicts the MIC risk and the corrosion rate in oil and gas pipelines

Based on the users' inputs of the prevailing operating conditions, MIC-Compass assesses the critical conditions for microbiologically influenced corrosion and other different types of corrosion, and determines the dominating corrosion process in the pipeline. The prediction results include the following:

- in-situ pH
- liquid velocity
- the maximum growth rate for microbiologically influenced corrosion
- the dominating corrosion process (MIC, CO2 corrosion, H2S corrosion, CO2-H2S mixed corrosion, O2 corrosion)
- the maximum corrosion rate for the identified dominating corrosion process
- the MIC risk ranking (very high, high, moderate, low, no risk)
- a chart showing MIC growth profile along the pipeline length

Pipeline Name/ID	ABC Pipeline XL	123		Date	
		Desig	n Data		
Pipe Length	km	120.000	Operating Pressure at Inlet	bar	50.00
Pipe ID	m	0.386	Operating Pressure at Outlet	bar	40.00
Remaining Pipe Wall Thickness	mm	10.000	Operating Temperature at Inlet	°C	48.00
Pipe Age	years	15.00	Operating Temperature at Outlet	°C	25.00
		Flow	Data		
Gas Flow Rate	MMSm³/d	4.0000	CO <sub>2</sub> in Gas	%mole	2.000
Oil/Condensate	m³/d	100.0000	H <sub>2</sub> S in Gas	%mole	0.000
Oil/Condensate Density	kg/m³	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m³/d	0.1000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m³	1024.000	Compressibility of Gas	0~1.0	0.900
		Water	Analysis		
Iron, Fe <sup>2+</sup>	ppm	0	Dissolved O <sub>2</sub>	ppm	0.500
Calcium, Ca <sup>2+</sup>	ppm	4,800	Sulphate, SO <sub>4</sub> <sup>2-</sup>	ppm	50
Magnesium, Mg <sup>2+</sup>	ppm	0	Strontium, Sr <sup>2+</sup>	ppm	0
Sodium, Na <sup>+</sup>	ppm	0	Bicarbonate, HCO <sub>3</sub>	ppm	49
Chloride, Cl <sup>-</sup>	ppm	10,000	All Organic Acids (HAc+Ac <sup>-</sup> )	ppm	100
Potassium, K <sup>+</sup>	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba <sup>2+</sup>	ppm	0	Nitrogen (as utilizable N)	ppm	10
		Othe	r Data		
Biocide in Ch	emical Injection	Not used	Presence of Debris on Pipe Bottom	Yes/No	Yes
Pig	gging Frequency	5 years or more	Total Downtime Todate	days	15
		Predictio	n Results		
MIC Rate (mm/y) v	s. Pipeline Lengtl	n (km)	in-situ pH	рН	4.75
.900			Liquid Velocity	m/s	1.300
.800			Max. MIC Rate	mm/y	0.000
.700			Corrosion Dominating Process	No Corro	osion!
.600			MIC Risk in the Pipeline	No Risk	
			No liquid water to support MIC activity. U	lse Spot Analysis	to assess ti
).500			MIC rate at low points where water drop		
).400			Spot Analys	ſ	
).300			Spot Location (KP)	km	60.000
).200			Temperature	°C	36.50
).100			Liquid Velocity	m/s	3.55
0.000 22.000 44.000 6	6.000 88.000	110.000 132.000	рН	рН	5.23
0.000 ZZ.000 44.000 bl	0.000 00.000	110.000 132.000	TDS	ppm	15,000
			Sulphate, $SO_4^{2-}$	ppm	50
			Predicted MIC Rate		

Figure 2 MIC-Compass assesses the critical conditions for microbiologically influenced corrosion. No water, no corrosion!

Using the "Spot Analysis" function, users can quickly assess the MIC rate at low points along a pipeline where water drop out may occur. Under the prevailing operating conditions in Figure 2 above, liquid water is generally not expected in the pipeline as the gas phase is under-saturated with water. However, at river crossings or some low points along the pipeline length, water drop out may occur. MIC-Compass gives users the power to assess the what-if scenarios.

ite	Date		123	ABC Pipeline XL	Pipeline Name/ID
		Data	Design		
50.00	bar	Operating Pressure at Inlet	120.000	km	Pipe Length
40.00	bar	Operating Pressure at Outlet	0.386	m	Pipe ID
48.00	°C	Operating Temperature at Inlet	10.000	mm	Remaining Pipe Wall Thickness
25.00	°C	Operating Temperature at Outlet	15.00	years	Pipe Age
		Pata	Flow D		
2.000	%mole	CO <sub>2</sub> in Gas	0.1000	MMSm³/d	Gas Flow Rate
0.000	%mole	H <sub>2</sub> S in Gas	100.0000	m³/d	Oil/Condensate
0.000	kg/d	Glycol Injection Rate	780.000	kg/m³	Oil/Condensate Density
0.700	0.5 ~ 1.0	Gas Gravity vs Air	0.1000	m³/d	Total Water at Inlet
0.900	0~1.0	Compressibility of Gas	1024.000	kg/m³	Water Density
		nalysis	Water Ar		
0.500	ppm	Dissolved O <sub>2</sub>	0	ppm	Iron, Fe <sup>2+</sup>
50	ppm	Sulphate, ${\rm SO_4}^{2^-}$	4,800	ppm	Calcium, Ca <sup>2+</sup>
0	ppm	Strontium, Sr <sup>2+</sup>	0	ppm	Magnesium, Mg <sup>2+</sup>
49	ppm	Bicarbonate, HCO <sub>3</sub>	0	ppm	Sodium, Na⁺
100	ppm	All Organic Acids (HAc+Ac <sup>-</sup> )	10,000	ppm	Chloride, Cl <sup>-</sup>
40	ppm	Total Carbon from Fatty Acids	0	ppm	Potassium, K <sup>+</sup>
10	ppm	Nitrogen (as utilizable N)	0	ppm	Barium, Ba <sup>2+</sup>
		Data	Other I		
Yes	Yes/No	Presence of Debris on Pipe Bottom	Not used 🗸	Biocide in Chemical Injection Not used	
15	days	Total Downtime Todate	3 years 🗸	ging Frequency	Pig
		Results	Prediction		
4.75	рН	in-situ pH	ı (km)	s. Pipeline Length	MIC Rate (mm/y) vs
0.142	m/s	Liquid Velocity			900
0.215	mm/y	Max. MIC Rate			800-
Corrosion		Corrosion Dominating Process			700
0.528	mm/y	Max. CO2 Corrosion Rate			700
	High	MIC Risk in the Pipeline			600-
					500-
	is	Spot Analys			400
60.000	km	Spot Location (KP)			300
36.50	°C	Temperature			200
3.55	m/s	Liquid Velocity			100
5.23	рН	рН			
15,000	ppm	TDS	110.000 132.000	5.000 88.000	0.000 22.000 44.000 66
50	ppm	Sulphate, SO <sub>4</sub> <sup>2-</sup>			
0.799	mm/y	Predicted MIC Rate			

Figure 3 MIC-Compass predicts that carbon dioxide corrosion is the corrosion dominating process under the prevailing operating conditions.

Under the prevailing operating conditions in Figure 3, MIC-Compass identifies CO2 corrosion as the dominating corrosion process and the maximum CO2 corrosion rate in the pipeline is 0.528 mm/y while the MIC growth rate is predicted to be 0.215 mm/y. The spot analysis at the user selected pipeline location gives a MIC growth rate of 0.799 mm/y.

Pipeline Name/ID	ABC Pipeline XL 1	123		Date	
		Design	ı Data		
Pipe Length	km	120.000	Operating Pressure at Inlet	bar	50.00
Pipe ID	m	0.386	Operating Pressure at Outlet	bar	40.00
Remaining Pipe Wall Thickness	mm	10.000	Operating Temperature at Inlet	°C	48.00
Pipe Age	years	15.00	Operating Temperature at Outlet	°C	25.00
		Flow	Data		
Gas Flow Rate	MMSm³/d	4.0000	CO <sub>2</sub> in Gas	%mole	0.200
Oil/Condensate	m³/d	400.0000	H₂S in Gas	%mole	0.000
Oil/Condensate Density	kg/m³	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m³/d	100.0000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m³	1024.000	Compressibility of Gas	0~1.0	0.900
		Water A	Analysis		
Iron, Fe <sup>2+</sup>	ppm	0	Dissolved O <sub>2</sub>	ppm	6.000
Calcium, Ca <sup>2+</sup>	ppm	4,800	Sulphate, SO <sub>4</sub> <sup>2-</sup>	ppm	50
Magnesium, Mg <sup>2+</sup>	ppm	0	Strontium, Sr <sup>2+</sup>	ppm	0
Sodium, Na <sup>+</sup>	ppm	0	Bicarbonate, HCO <sub>3</sub>	ppm	49
Chloride, Cl <sup>-</sup>	ppm	10,000	All Organic Acids (HAc+Ac <sup>-</sup> )	ppm	100
Potassium, K <sup>+</sup>	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba <sup>2+</sup>	ppm	0	Nitrogen (as utilizable N)	ppm	10
		Other	Data		
Biocide in Ch	emical Injection	Not used 🗸	Presence of Debris on Pipe Bottom	Yes/No	No
Pię	gging Frequency	3 years 🔻	Total Downtime Todate	days	7
		Prediction	n Results		
MIC Rate (mm/y) v	s. Pipeline Length	ı (km)	in-situ pH	рН	5.75
900			Liquid Velocity	m/s	3.953
800			Max. MIC Rate	mm/y	0.363
700			Corrosion Dominating Process	O2 Con	
700-			Max. O2 Corrosion Rate	mm/y	0.733
600-			MIC Risk in the Pipeline	Moderate	
500					
400			Spot Analys	sis	
			Spot Location (KP)	km	60.000
300-			Temperature	°C	36.50
200-			Liquid Velocity	m/s	1.00
100-			рН	pН	4.00
0.000 22.000 44.000 60	6.000 88.000 1	10.000 132.000	TDS	ppm	100,000
			Sulphate, SO <sub>4</sub> <sup>2-</sup>	ppm	50
			Julphate, 304	PPIII	

Figure 4 MIC-Compass predicts oxygen corrosion is the corrosion dominating process under the prevailing operating conditions.

Under the prevailing operating conditions in Figure 4 above, MIC-Compass identifies oxygen corrosion as the dominating corrosion process and the maximum O2 corrosion rate is 0.733 mm/y while the maximum MIC growth rate is 0.363 mm/y.

MIC-Compass is a powerful software tool for internal corrosion direct assessment and pipeline integrity management. Both prevailing and historical pipeline operating data can be used to model and predict the growth rates of microbiologically influenced corrosion and other different type of corrosion mechanisms (CO2 corrosion, H2S corrosion, CO2-H2S mixed corrosion, O2 corrosion) in oil and gas pipelines.

Click here to contact us for licensing details and experience the power of MIC-Compass.

MIC-Compass, giving you the right directions in the modeling and prediction of Microbiologically Influenced Corrosion.

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