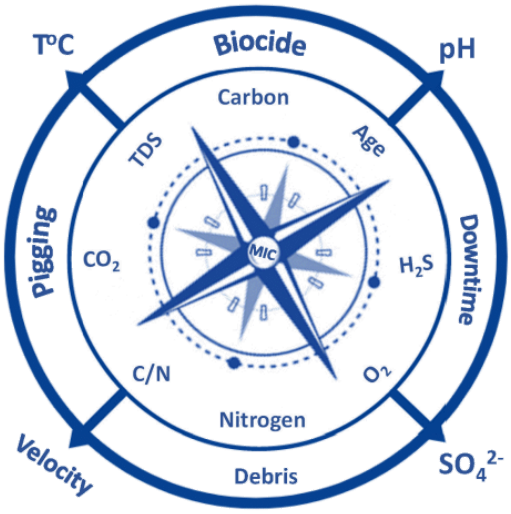


Corrosion Modeling Software and Corrosion Prediction Software Series

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

High-Value Software Solutions to Costly Corrosion

Version 12.4

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

Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plug-ins

Contact Us for Licensing Details

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.

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

Pipeline Name/ID	ABC Pipeline XL 123	Date

Design 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	$MMSm^3/d$	4.0000	CO_2 in Gas	%mole	0.600
Oil/Condensate	m^3/d	400.0000	H_2S in Gas	%mole	0.000
Oil/Condensate Density	kg/m^3	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m^3/d	20.0000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m^3	1024.000	Compressibility of Gas	0 ~ 1.0	0.900

Water Analysis

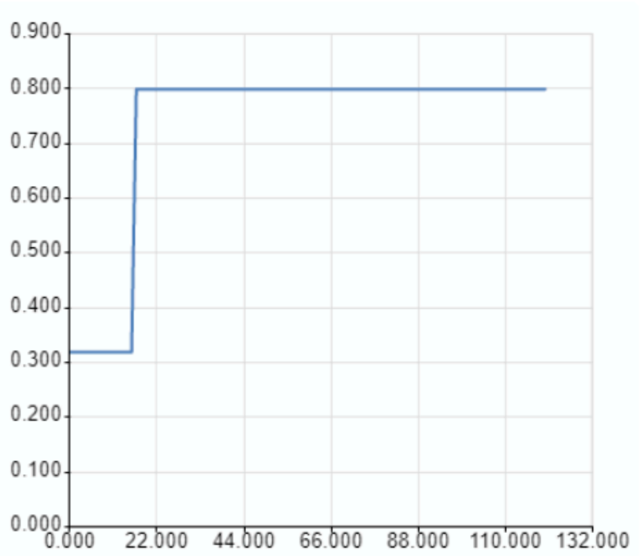
Iron, Fe^{2+}	ppm	0	Dissolved O_2	ppm	0.500
Calcium, Ca^{2+}	ppm	4,800	Sulphate, SO_4^{2-}	ppm	50
Magnesium, Mg^{2+}	ppm	0	Strontium, Sr^{2+}	ppm	0
Sodium, Na^+	ppm	0	Bicarbonate, HCO_3^-	ppm	49
Chloride, Cl^-	ppm	10,000	All Organic Acids ($HAc+Ac^-$)	ppm	100
Potassium, K^+	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba^{2+}	ppm	0	Nitrogen (as utilizable N)	ppm	10

Other Data

Biocide in Chemical Injection	Not used	Presence of Debris on Pipe Bottom	Yes/No	Yes
Pigging Frequency	5 years or more	Total Downtime Todate	days	15

Prediction Results

MIC Rate (mm/y) vs. Pipeline Length (km)



in-situ pH	pH	5.27
Liquid Velocity	m/s	3.547
Max. MIC Rate	mm/y	0.799
Corrosion Dominating Process		MIC
Max. MIC Rate	mm/y	0.799
MIC Risk in the Pipeline	High	

Spot Analysis

Spot Location (KP)	km	60.000
Temperature	°C	36.50
Liquid Velocity	m/s	3.55
pH	pH	5.23
TDS	ppm	15,000
Sulphate, SO_4^{2-}	ppm	50
Predicted MIC Rate	mm/y	0.799

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, CO_2 corrosion, H_2S corrosion, CO_2-H_2S mixed corrosion, O_2 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

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Flow Data

Gas Flow Rate	$MMSm^3/d$	4.0000	CO_2 in Gas	%mole	2.000
Oil/Condensate	m^3/d	100.0000	H_2S in Gas	%mole	0.000
Oil/Condensate Density	kg/m^3	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m^3/d	0.1000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m^3	1024.000	Compressibility of Gas	0 ~ 1.0	0.900

Water Analysis

Iron, Fe^{2+}	ppm	0	Dissolved O_2	ppm	0.500
Calcium, Ca^{2+}	ppm	4,800	Sulphate, SO_4^{2-}	ppm	50
Magnesium, Mg^{2+}	ppm	0	Strontium, Sr^{2+}	ppm	0
Sodium, Na^+	ppm	0	Bicarbonate, HCO_3^-	ppm	49
Chloride, Cl^-	ppm	10,000	All Organic Acids ($HAc+Ac^-$)	ppm	100
Potassium, K^+	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba^{2+}	ppm	0	Nitrogen (as utilizable N)	ppm	10

Other Data

Biocide in Chemical Injection	Not used	Presence of Debris on Pipe Bottom	Yes/No	Yes
Pigging Frequency	5 years or more	Total Downtime Todate	days	15

Prediction Results

MIC Rate (mm/y) vs. Pipeline Length (km)

in-situ pH	pH	4.75
Liquid Velocity	m/s	1.300
Max. MIC Rate	mm/y	0.000
Corrosion Dominating Process		No Corrosion!
MIC Risk in the Pipeline	No Risk	

No liquid water to support MIC activity. Use Spot Analysis to assess the MIC rate at low points where water drop out may occur.

Spot Analysis

Spot Location (KP)	km	60.000
Temperature	°C	36.50
Liquid Velocity	m/s	3.55
pH	pH	5.23
TDS	ppm	15,000
Sulphate, SO_4^{2-}	ppm	50
Predicted MIC Rate	mm/y	0.799

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.

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Pipe Age	years	15.00	Operating Temperature at Outlet	°C	25.00

Flow Data

Gas Flow Rate	$MMSm^3/d$	0.1000	CO_2 in Gas	%mole	2.000
Oil/Condensate	m^3/d	100.0000	H_2S in Gas	%mole	0.000
Oil/Condensate Density	kg/m^3	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m^3/d	0.1000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m^3	1024.000	Compressibility of Gas	0 ~ 1.0	0.900

Water Analysis

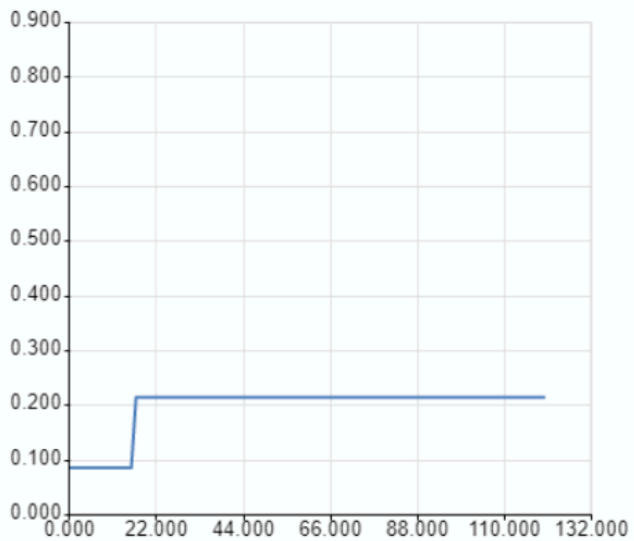
Iron, Fe^{2+}	ppm	0	Dissolved O_2	ppm	0.500
Calcium, Ca^{2+}	ppm	4,800	Sulphate, SO_4^{2-}	ppm	50
Magnesium, Mg^{2+}	ppm	0	Strontium, Sr^{2+}	ppm	0
Sodium, Na^+	ppm	0	Bicarbonate, HCO_3^-	ppm	49
Chloride, Cl^-	ppm	10,000	All Organic Acids ($HAc+Ac^-$)	ppm	100
Potassium, K^+	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba^{2+}	ppm	0	Nitrogen (as utilizable N)	ppm	10

Other Data

Biocide in Chemical Injection	Not used	Presence of Debris on Pipe Bottom	Yes/No	Yes
Pigging Frequency	3 years	Total Downtime Todate	days	15

Prediction Results

MIC Rate (mm/y) vs. Pipeline Length (km)



in-situ pH	pH	4.75
Liquid Velocity	m/s	0.142
Max. MIC Rate	mm/y	0.215
Corrosion Dominating Process	CO2 Corrosion	
Max. CO2 Corrosion Rate	mm/y	0.528
MIC Risk in the Pipeline	High	

Spot Analysis

Spot Location (KP)	km	60.000
Temperature	°C	36.50
Liquid Velocity	m/s	3.55
pH	pH	5.23
TDS	ppm	15,000
Sulphate, SO_4^{2-}	ppm	50
Predicted MIC Rate	mm/y	0.799

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 CO_2 corrosion as the dominating corrosion process and the maximum CO_2 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.

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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	$MMSm^3/d$	4.0000	CO_2 in Gas	%mole	0.200
Oil/Condensate	m^3/d	400.0000	H_2S in Gas	%mole	0.000
Oil/Condensate Density	kg/m^3	780.000	Glycol Injection Rate	kg/d	0.000
Total Water at Inlet	m^3/d	100.0000	Gas Gravity vs Air	0.5 ~ 1.0	0.700
Water Density	kg/m^3	1024.000	Compressibility of Gas	0 ~ 1.0	0.900

Water Analysis

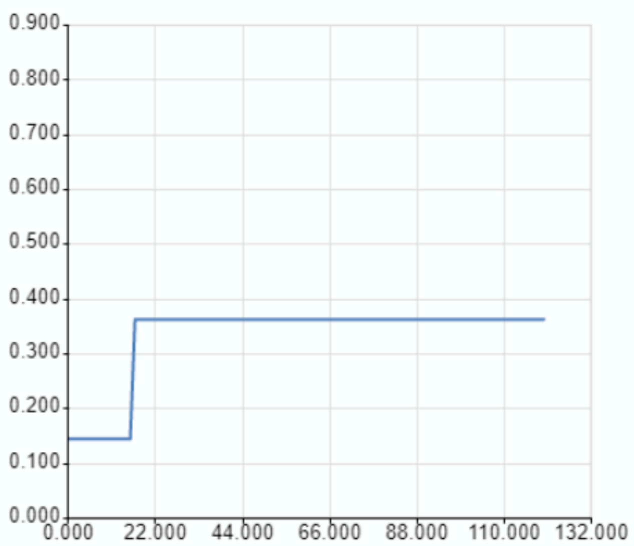
Iron, Fe^{2+}	ppm	0	Dissolved O_2	ppm	6.000
Calcium, Ca^{2+}	ppm	4,800	Sulphate, SO_4^{2-}	ppm	50
Magnesium, Mg^{2+}	ppm	0	Strontium, Sr^{2+}	ppm	0
Sodium, Na^+	ppm	0	Bicarbonate, HCO_3^-	ppm	49
Chloride, Cl^-	ppm	10,000	All Organic Acids ($HAc+Ac^-$)	ppm	100
Potassium, K^+	ppm	0	Total Carbon from Fatty Acids	ppm	40
Barium, Ba^{2+}	ppm	0	Nitrogen (as utilizable N)	ppm	10

Other Data

Biocide in Chemical Injection	Not used	Presence of Debris on Pipe Bottom	Yes/No	No
Pigging Frequency	3 years	Total Downtime Todate	days	7

Prediction Results

MIC Rate (mm/y) vs. Pipeline Length (km)



in-situ pH	pH	5.75
Liquid Velocity	m/s	3.953
Max. MIC Rate	mm/y	0.363
Corrosion Dominating Process		O2 Corrosion
Max. O2 Corrosion Rate	mm/y	0.733
MIC Risk in the Pipeline	Moderate	

Spot Analysis

Spot Location (KP)	km	60.000
Temperature	°C	36.50
Liquid Velocity	m/s	1.00
pH	pH	4.00
TDS	ppm	100,000
Sulphate, SO_4^{2-}	ppm	50
Predicted MIC Rate	mm/y	0.039

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.