

Biofilm

HS^-



SO_4^{2-}

SRB attack

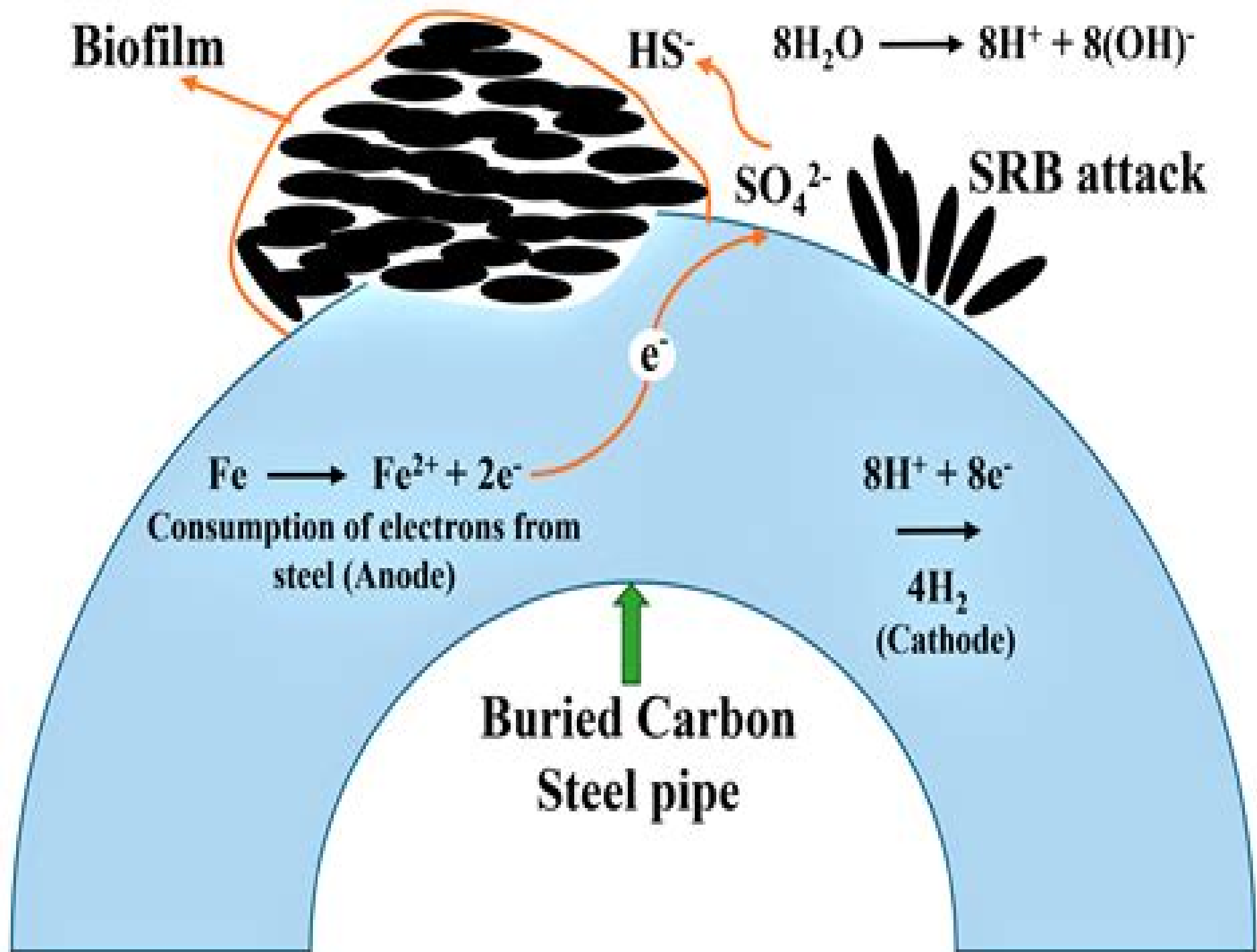
e^-



Consumption of electrons from
steel (Anode)



**Buried Carbon
Steel pipe**



Microbiologically Influenced Corrosion In Pipelines

Peter James Smith



Microbiologically Influenced Corrosion In Pipelines:

Microbiologically Influenced Corrosion in Pipelines Daniel Pope, 1996-11-01 **Microbiologically Influenced Corrosion in the Upstream Oil and Gas Industry** Torben Lund Skovhus, Dennis Enning, Jason Lee, 2017-03-03

Microorganisms are ubiquitously present in petroleum reservoirs and the facilities that produce them. Pipelines, vessels, and other equipment used in upstream oil and gas operations provide a vast and predominantly anoxic environment for microorganisms to thrive. The biggest technical challenge resulting from microbial activity in these engineered environments is the impact on materials integrity. Oilfield microorganisms can affect materials integrity profoundly through a multitude of elusive bio-chemical mechanisms collectively referred to as microbiologically influenced corrosion (MIC). MIC is estimated to account for 20 to 30% of all corrosion-related costs in the oil and gas industry. This book is intended as a comprehensive reference for integrity engineers, production chemists, oilfield microbiologists, and scientists working in the field of petroleum microbiology or corrosion. Exhaustively researched by leaders from both industry and academia, this book discusses the latest technological and scientific advances as well as relevant case studies to convey to readers an understanding of MIC and its effective management.

Failure Assessment of Pipelines Due to Microbiologically Influenced Corrosion Andre De Araujo Abilio, 2022

Microbiologically influenced corrosion (MIC) is a difficult degradation mechanism to diagnose in pipeline systems due to the complex interaction between biotic (i.e. microbial) and abiotic (e.g. fluid chemistry, pipe vessel metallurgy, corrosion, and operating conditions) factors. This complexity often makes it difficult to accurately assess pipeline failures due to MIC. However, even with available data, failure investigators often face a number of challenges in diagnosing MIC, such as how to properly integrate the available datasets, questions regarding data accuracy (e.g. confidence in the sampling and/or analysis method used) and lack of available information from operators (e.g. missing data). As a result, practical MIC failure assessments are most often performed by experts or specialists with significant knowledge and working experience in this topic. Based on these issues, the objectives of this thesis are three-fold: 1) to quantify the actual prevalence of MIC-related pipeline failures in Alberta's oil and gas sector; 2) to perform a gap analysis of failure investigation methods used to assess these pipeline failures; and 3) to develop a novel expert system based on machine learning to assist both experts and non-experts in assessing potential MIC-related pipeline failures. The first part of this study highlights a review and analysis of MIC-related pipeline incidents in the province of Alberta, Canada, over a three-year period (2017-2019). This review was used to quantify the occurrence of MIC failures relative to other corrosion mechanisms and to conduct a gap analysis of MIC failure investigation techniques being used relative to the current state of the art. Over this three-year period, MIC was found to be responsible for 13.6% and 4.8% of all pipeline leak incidents due to internal and external corrosion, respectively, either as the main failure mechanism or as a contributing factor. Most of these failures were seen to occur in small-diameter upstream pipelines with less than or equal to 220.3 mm outside diameter carrying mainly multiphase fluids (oil-water emulsions) or produced water. In

terms of the failure investigation methods currently being used it was noted that there was some inconsistency among reports and a number of important gaps were identified Various assessments lacked microbiological test data in particular tests which specifically identify microbial functional groups or speciation which is critical to confirm observed corrosion mechanisms Furthermore a number of these assessments identified MIC primarily on the basis of corrosion morphology which has been shown to be an incorrect assumption and approach without additional evidence Details related to sampling methods were also lacking in these assessments which created some uncertainty as to the quality of data obtained Overall most assessments did a reasonable job in characterizing and including chemical solids fluids and corrosion products metallurgical corrosion and operating data However the integration of these various layers of evidence i e connecting corrosion to microbiological activity and eliminating possible abiotic corrosion mechanisms was missing in many reports The second part of this study highlights the modeling of an expert system for the classification of internal microbiologically influenced corrosion MIC failures related to pipelines in the upstream oil and gas industry The model is based on machine learning artificial neural network and involves the participation of 15 MIC subject matter experts SMEs Each expert evaluated a number of model case studies representative of both MIC and non MIC related upstream pipeline failures The model accounts for variations in microbiological testing methods microbiological sample types degradation morphology among others and also incorporates cases with select missing datasets which is commonly found in actual failure assessments The output classifications comprised elements of both potential for MIC and confidence in the data available The results were contrasted for 5 and 3 output classification models 5OC and 3OC respectively The 5OC model had an overall accuracy of 62 0% while the simpler 3OC model had a better accuracy of 74 8% This modelling exercise has demonstrated that knowledge from subject matter experts can be captured in a reasonably effective model to screen for possible MIC failures It is hoped that this study contributes to a better understanding of the prevalence of MIC in the oil and gas sector and highlights the key areas necessary to improve the diagnosis of MIC failures in the future

Failure Analysis of Microbiologically Influenced Corrosion Richard B. Eckert, Torben Lund Skovhus, 2021-11-07 Failure Analysis of Microbiologically Influenced Corrosion serves as a complete guide to corrosion failure analysis with an emphasis on the diagnosis of microbiologically influenced corrosion MIC By applying the principles of chemistry microbiology and metallurgy readers will be able to reliably determine the mechanistic cause of corrosion damage and failures and select the appropriate methods for mitigating future corrosion incidents FEATURES Provides background information on the forensic process types of data or evidence needed to perform the analysis industrial case studies details on the MIC failure analysis process and protocols for field and lab use Presents up to date advances in molecular technologies and their application to corrosion failure investigations Offers specific guidelines for conducting MIC failure analyses and case studies to illustrate their application Examines state of the art information on MIC analytical tools and methods With authors with expertise in

microbiology corrosion materials and failure investigation this book provides tools for engineers scientists and technologists to successfully combat MIC issues Microbiologically Influenced Corrosion Brenda J. Little,Jason S. Lee,2007-03-30 A multi disciplinary multi industry overview of microbiologically influenced corrosion with strategies for diagnosis and control or prevention Microbiologically Influenced Corrosion helps engineers and scientists understand and combat the costly failures that occur due to microbiologically influenced corrosion MIC This book combines recent findings from diverse disciplines into one comprehensive reference Complete with case histories from a variety of environments it covers Biofilm formation Causative organisms relating bacteria and fungi to corrosion mechanisms for groups of metals Diagnosing and monitoring MIC Electrochemical techniques with an overview of methods for detection of MIC The impact of alloying elements including antimicrobial metals and design features on MIC MIC of non metallics Strategies for control or prevention of MIC including engineering chemical and biological approaches This is a valuable all inclusive reference for corrosion scientists engineers and researchers as well as designers managers and operators **Failure Analysis of**

Microbiologically Influenced Corrosion Richard B. Eckert,Torben Lund Skovhus,2021-11-07 Failure Analysis of Microbiologically Influenced Corrosion serves as a complete guide to corrosion failure analysis with an emphasis on the diagnosis of microbiologically influenced corrosion MIC By applying the principles of chemistry microbiology and metallurgy readers will be able to reliably determine the mechanistic cause of corrosion damage and failures and select the appropriate methods for mitigating future corrosion incidents FEATURES Provides background information on the forensic process types of data or evidence needed to perform the analysis industrial case studies details on the MIC failure analysis process and protocols for field and lab use Presents up to date advances in molecular technologies and their application to corrosion failure investigations Offers specific guidelines for conducting MIC failure analyses and case studies to illustrate their application Examines state of the art information on MIC analytical tools and methods With authors with expertise in microbiology corrosion materials and failure investigation this book provides tools for engineers scientists and technologists to successfully combat MIC issues *Failure Modes, Effects and Causes of Microbiologically Influenced Corrosion* Reza Javaherdashti,Farzaneh Akvan,2019-10-22 Failure Modes Effects and Causes of Microbiologically Influenced Corrosion Advanced Perspectives and Analysis presents academic research about microbial corrosion MIC integrating it into engineering applications that result in a more thorough understanding of MIC and how it is recognized and treated In addition new concepts that will be useful in understanding integrity and corrosion management practices are explored This book will be useful for industry professionals particularly maintenance and operation engineers corrosion and material engineers and R D personnel working in the field of corrosion protection Focuses on the skills and knowledge necessary to understand how Failure modes and why Effects and Causes materials fail Explains why corrosion control measures such as the use of coatings cathodic protection and inhibitors are useful Discusses the practical side of MIC treatment in terms of

fundamental concepts of time and cost of operation **A Practical Manual on Microbiologically Influenced Corrosion**
Gregory Kobrin, John G. Stoecker, 2001 Microbiologically Influenced Corrosion (MIC), 1988 This guide is designed to help
gas industry personnel determine whether or not the corrosion occurring at a particular site is microbiologically influenced
corrosion It primarily addresses external pipe corrosion and readily accessible internal pipe corrosion sites *Detection,
Testing, and Evaluation of Microbiologically Influenced Corrosion on Internal Surfaces of Pipelines*, 2012

Microbiologically Influenced Corrosion on Pipeline Steel Used for Transportation of Oil Hussain H. Obaid
Almahamedh, 2008 **ENVIRONMENTAL BENIGN MITIGATION OF MICROBIOLOGICALLY INFLUENCED
CORROSION (MIC)**, 2002 The overall program objective is to develop and evaluate environmental benign agents or
products that are effective in the prevention inhibition and mitigation of microbially influenced corrosion MIC in the internal
surfaces of metallic natural gas pipelines The goal is one or more environmental benign a k a green products that can be
applied to maintain the structure and dependability of the natural gas infrastructure The technical approach for this quarter
has been to evaluate a number of real world pipeline sources for microbial communities or consortia that form biofilms under
laboratory simulations of pipelines The microorganisms will be identified using classical and molecular microbiological tools
and there activities under pipeline simulating conditions will be studied The quarter saw the collection of the first samples
from the industry for isolation of the microorganisms as well as the design and construction of the laboratory scale pipeline
simulators Methods development for MIC and biofilm microbial isolations and identification and laboratory design and
construction of pipeline simulators were the only activities At this stage of the study first quarter only preliminary results are
available **Microbially Influenced Corrosion of Materials** Ewald Heitz, Hans-Curt Flemming, Wolfgang
Sand, 1996-09-13 Corrosion has been largely considered to be caused only abiotically without regard of any biological
influence However corrosion of organic materials metals minerals and plastics can be strongly influenced by microorganisms
enhancing the kinetics of the corrosion processes This book presents case histories theoretical explanations and methods for
the detection sanitation and prevention of biologically influenced corrosion Field Guide for Investigating Internal
Corrosion of Pipelines Richard Eckert, 2003 *A Predictive Model for Microbiologically Influenced Corrosion (MIC) in
Sub-sea Production Pipelines* Peter James Smith, 2009 **Standard Test Method Detection, Testing, and Evaluation of
Microbiologically Influenced Corrosion (MIC) on External Surfaces of Buried Pipelines** National Association of
Corrosion Engineers. Unit Committee T-5A on Corrosion in Chemical Processes, 2006 **Microbiologically Influenced
Corrosion of Buried Mild Steel Pipes** Arjumand Shah Bano, Javed Iqbal Qazi, 2012-04 Within the biosphere every object is
influenced by microbial activities A very unfamiliar case is represented by the microorganisms involved in the process of
corrosion of different metals and their alloys Many workers have reported bacteria responsible for initiating accelariting and
promoting the process of corrosion While several recent authors have also documented corrosion inhibiting controlling roles

of microorganisms It appears that like a healthier balance between the normal microbiota and pathogens required for maintaining health of a host a comparable balance among the members of microbial community of soil is required for protecting the buried mild steel pipes from corrosion based losses This work reports isolation of both corrosion enhancing as well as corrosion controlling bacteria from an identified location The bacterial isolates were then studied under laboratory but field simulated conditions to explore the roles of the monocultures of both catogaries of the bacteria While effects of their co cultures have also been delineated in comparable experimental set up The findings are helpful in controlling corrosion of soil buried mild steel pipes

Corrosion Cost and Preventive Strategies in the United States ,2002 This report describes the annual total cost of metallic corrosion in the United States and preventive strategies for optimum corrosion management The current study showed that technological changes have provided many new ways to prevent corrosion and there has been improved use of available corrosion management techniques However better corrosion management can be achieved using preventive strategies in non technical and technical areas

Materials Performance ,2006 **Microbial Corrosion** C. A. C. Sequeira,A. K. Tiller,1992 Topics covered include metallurgical considerations effect of environments the role which biofilms play progress made in analytical procedures and rapid test methods and laboratory procedures for evaluating biocide performance

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