

**Biofilm**

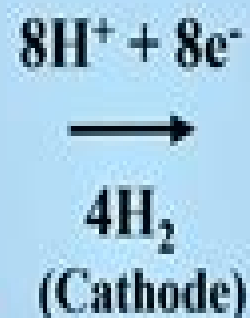
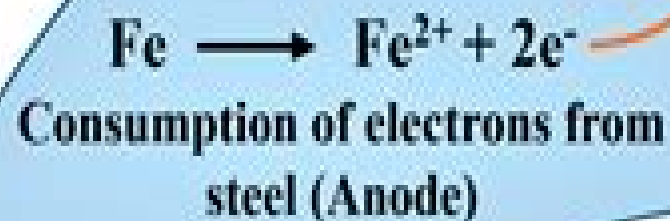
$\text{HS}^-$



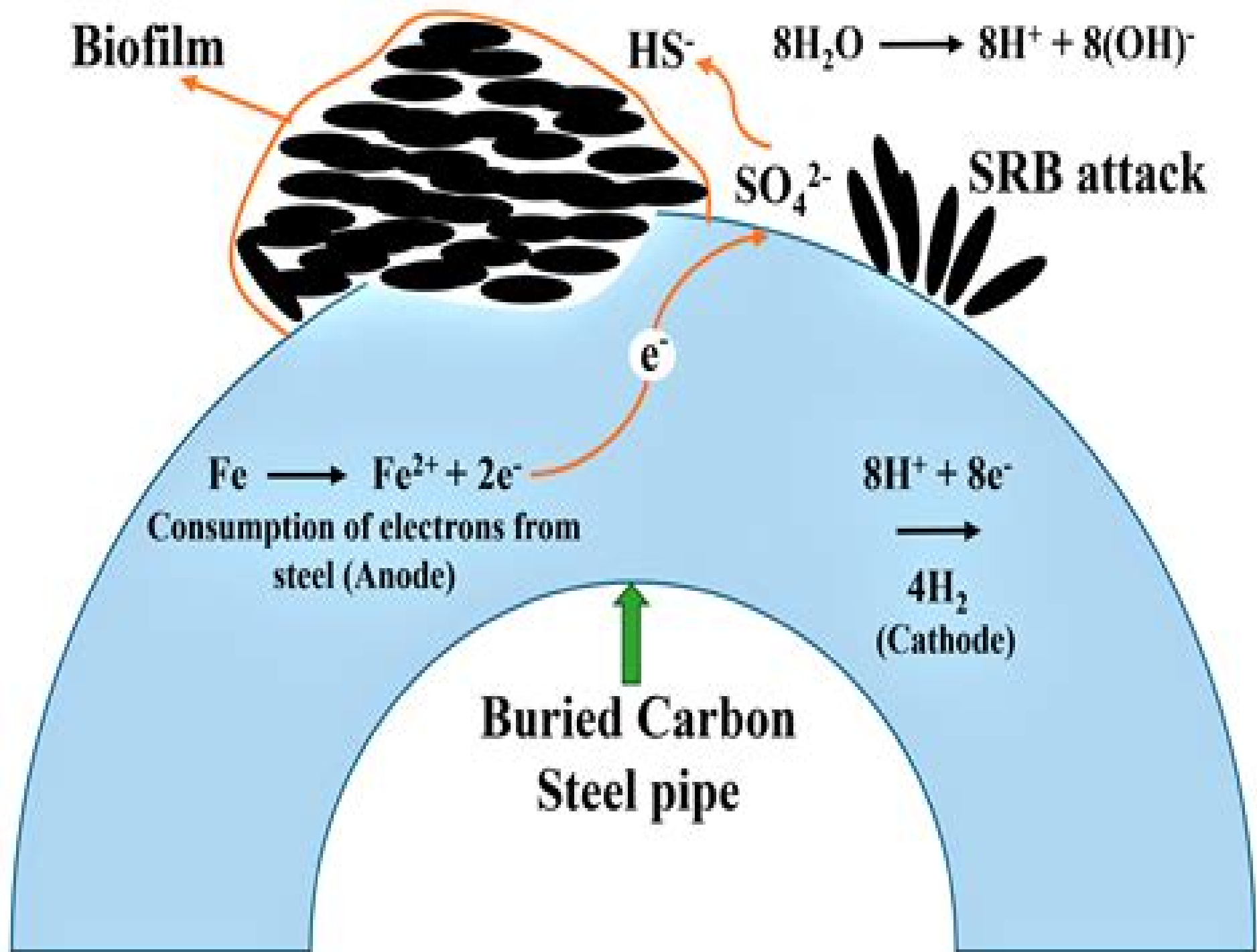
$\text{SO}_4^{2-}$

**SRB attack**

$\text{e}^-$



**Buried Carbon  
Steel pipe**



# Microbiologically Influenced Corrosion In Pipelines

**Andre De Araujo Abilio**



## **Microbiologically Influenced Corrosion In Pipelines:**

*Microbiologically Influenced Corrosion in Pipelines* Daniel Pope, 1996-11-01  
**Corrosion** Reza Javaherdashti, 2016-09-29 Significantly extended from the first edition this book presents the basics of microbiologically influenced corrosion MIC in an accessible and concise manner It explores strategies for recognizing understanding mitigating and preventing this type of corrosion and investigates this topic from the point of view of an engineer Chapters cover issues including stress corrosion cracking and microbial corrosion the pros and cons of biocides the involvement of magnetic bacteria in microbial corrosion and cathodic protection based on recent research in microbial environments The 2nd Edition provides new material examining the following topics The corrosion related bacteria clostridia Mathematical modelling of MIC in particular fuzzy logic A comparison of culture independent methods with culture dependent methods Further practical strategies for dealing with MIC Natural biocides This book has provided course material for the author s microbial corrosion workshops around the world and it presents an invaluable resource to corrosion and integrity professionals working in a wide range of industries including power generation oil and gas marine and mining It is also intended for students and academics of corrosion engineering materials science microbiology chemical engineering and welding  
**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  
**Microbiologically Influenced Corrosion** Brenda J.

Little, Jason S. Lee, 2007-03-31 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

**Microbiologically Influenced Corrosion in the Upstream Oil and Gas Industry** Torben Lund Skovhus, Dennis Enning, Jason S. 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 Microbiologically Influenced Corrosion Testing Jeffery R. Kearns, Jeffrey R. Kearns, Brenda J. Little, 1994 The proceedings of the First International Symposium on title held in Miami during November of 1992 comprise a keynote address and 21 papers arranged in six topical sections electrochemical methods on line monitoring methods surface analysis techniques SRB characterization non metallic mate **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 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

*Hydrostatic Testing, Corrosion, and Microbiologically Influenced Corrosion* Reza Javaherdashti, Farzaneh Akvan, 2017-03-16 Hydrostatic Testing Corrosion and Microbiologically Influenced Corrosion A Field Manual for Control and Prevention teaches industry professionals managers and researchers how to combat corrosion failure associated with hydrotesting It discusses how a test liquid must be selected how corrosion by bacteria should be controlled and how to eliminate the risk of leakage Rather than teaching how hydrotests should be conducted it helps the reader evaluate the quality of a hydrotest that s already been conducted in terms of oxygen scavenger use biocide testing inhibitor addition and water quality and explains the tasks that top and middle management must ensure are taken with respect to corrosion assessment of hydrotesting The manual also discusses microbiologically influenced corrosion MIC as the main corrosion mechanism related to post hydrotesting and offers essential knowledge on combating this corrosion process In addition to being a manual for top and middle management on how to deal with corrosion this book also *Oil and Gas Pipelines* R. Winston Revie, 2025-03-18 Discover the integrity safety and security of new and aging oil and gas pipelines in this comprehensive reference guide Oil and gas pipelines are typically used to transport oil and gas but can be adapted to transport ethanol carbon dioxide hydrogen and more A pipeline network is an efficient method for transporting any number of energy providing products but safety and integrity are critical aspects of pipeline integrity management The demand for pipeline safety and security is increasing in the face of more stringent standards and deepening environmental concerns

including those related to climate change Oil and Gas Pipelines Integrity Safety and Security Handbook provides a comprehensive introduction to the integrity of new and aging pipelines and their management repair and maintenance All major varieties of pipeline are included along with all pertinent public safety and environmental protections Now fully updated to reflect the latest research and technological developments the book is a critical contribution to the reliability and safety of the global energy grid and ongoing efforts at carbon capture utilization and storage Readers of the second edition of Oil and Gas Pipelines will also find 26 new chapters including a new section on the digitalization of pipelines Detailed discussion of topics including management of geohazards mechanical damage internal corrosion monitoring and many more Extensive case histories with practical accompanying solutions Oil and Gas Pipelines is ideal for engineers scientists technologists environmentalists students and others who need to understand the basics of pipeline technology as it pertains to energy deliverability environmental protection public safety and the important role of pipelines and pipeline security to ensure energy security during the energy transition

**Guide to the Practical Use of Chemicals in Refineries and Pipelines** Johannes Karl Fink, 2016-05-09 Guide to Practical Use of Chemicals in Refineries and Pipelines delivers a well rounded collection of content references and patents to show all the practical chemical choices available for refinery and pipeline usage along with their purposes benefits and general characteristics Covering the full spectrum of downstream operations this reference solves the many problems that engineers and managers currently face including corrosion leakage in pipelines and pretreatment of heavy oil feedstocks something that is of growing interest with today s unconventional activity Additional coverage on special refinery additives and justification on why they react the way they do with other chemicals and feedstocks is included along with a reference list of acronyms and an index of chemicals that will give engineers and managers the opportunity to recognize new chemical solutions that can be used in the downstream industry Presents tactics practitioners can use to effectively locate and utilize the right chemical application specific to their refinery or pipeline operation Includes information on how to safely perform operations with coverage on environmental issues and safety including waste stream treatment and sulfur removal Helps readers understand the composition and applications of chemicals used in oil and gas refineries and pipelines along with where they should be applied and how their structure interacts when mixed at the refinery

**PRICM 8** Fernand D. S. Marquis, 2013-09-05 PRICM 8 features the most prominent and largest scale interactions in advanced materials and processing in the Pacific Rim region The conference is unique in its intrinsic nature and architecture which crosses many traditional discipline and cultural boundaries The CD is a comprehensive collection of papers from the 15 symposia presented at this event

[Polymetallic Coatings to Control Biofouling in Pipelines](#) Vinita Vishwakarma, Dawn S S, K. Gobi Saravanan, A. M. Kamalan Kirubaharan, Saravanamuthu Vigneswaran, Gayathri Naidu, 2021-09-13 Most of the pipelines used for the transport of various fluids are susceptible to the formation of biofilms and the undesirable accumulation of microorganisms in pipelines leads to biodeterioration and

increases the maintenance cost of the pipelines This book focuses on nanostructured polymetallic coatings for corrosion and biofouling protection in offshore oil and gas pipelines marine pipelines ship structures and port facilities and corrosion resistance surfaces of several engineered structures Considering various reasons of biofouling in pipelines that transport crude and refined petroleum gas biofuels and other fluids including sewage slurry and water for drinking or irrigation the underlying mechanism is thoroughly explained A comparison of various protective techniques is also highlighted for the choice of methods for specific applications Features Provides information on biofouling control with broad significance and applicability in various industrial and research areas Discusses microbially induced corrosion on biofuel transporting pipelines Includes data from experiments conducted to overcome biofouling and biocorrosion Gives out particular attention to metallic coatings and environmental considerations Explores novel technologies preventing biofouling on metallic and polymeric substrates This book is for researchers and graduate students in Coatings and Paints Microbiology Bioprocess Engineering Biotechnology Industrial Engineering Mechanical and Chemical Engineering Marine Engineering Surface and Corrosion Engineering and Water and Wastewater Treatment

### **Corrosion Inhibitors in the Oil and Gas Industry**

Viswanathan S. Saji, Saviour A. Umoren, 2020-02-10 Provides comprehensive coverage of corrosion inhibitors in the oil and gas industries Considering the high importance of corrosion inhibitor development for the oil and gas sectors this book provides a thorough overview of the most recent advancements in this field It systematically addresses corrosion inhibitors for various applications in the oil and gas value chain as well as the fundamentals of corrosion inhibition and interference of inhibitors with co additives Corrosion Inhibitors in the Oil and Gas Industries is presented in three parts The first part on Fundamentals and Approaches focuses on principles and processes in the oil and gas industry the types of corrosion encountered and their control methods environmental factors affecting inhibition material selection strategies and economic aspects of corrosion The second part on Choice of Inhibitors examines corrosion inhibitors for acidizing processes inhibitors for sweet and sour corrosion inhibitors in refinery operations high temperature corrosion inhibitors inhibitors for challenging corrosive environments inhibitors for microbiologically influenced corrosion polymeric inhibitors vapor phase inhibitors and smart controlled release inhibitor systems The last part on Interaction with Co additives looks at industrial co additives and their interference with corrosion inhibitors such as antisclalants hydrate inhibitors and sulfide scavengers Presents a well structured and systematic overview of the fundamentals and factors affecting corrosion Acts as a handy reference tool for scientists and engineers working with corrosion inhibitors for the oil and gas industries Collectively presents all the information available on the development and application of corrosion inhibitors for the oil and gas industries Offers a unique and specific focus on the oil and gas industries Corrosion Inhibitors in the Oil and Gas Industries is an excellent resource for scientists in industry as well as in academia working in the field of corrosion protection for the oil and gas sectors and will appeal to materials scientists electrochemists chemists and chemical engineers

Petroleum Microbial Biotechnology:



Challenges and Prospects Wael A. Ismail, Jonathan D. Van Hamme, John J. Kilbane, Ji-Dong Gu, 2017-09-08 Petroleum hydrocarbons are both a product of and rich substrate for microorganisms from across all Domains of life Rooted deeply in the history of microbiology hydrocarbons have been studied as sources of carbon and energy for microorganisms for over a century As global demand for petroleum and its refined products continues to rise so do challenges associated with environmental pollution oil well souring infrastructure corrosion oil recovery transport refining and upgrading of heavy crude oils and bitumens Advances in genomics synthetic biology and metabolic engineering has invigorated interest in petroleum microbial biotechnology as interest grows in technologies for in situ methane production biodesulfurization and bidenitrogenation bio upgrading of heavy crudes microbial enhanced oil recovery corrosion control and biocatalysts for generating value added products Given the complexity of the global petroleum industry and the harsh conditions in which it operates a deeper understanding of the ecophysiology of aerobic and anaerobic microbial communities that have associations with petroleum hydrocarbons is needed if robust technologies are to be deployed successfully This research topic highlights recent advances in microbial enhanced oil recovery methanogenic hydrocarbon metabolism and carbon dioxide sequestration bioremediation microbiologically influenced corrosion biodesulfurization and the application of metagenomics to better understand microbial communities associated with petroleum hydrocarbons

Microbially Induced Corrosion and its Mitigation Ajay K. Singh, 2020-09-24 This brief covers case studies on Microbial Induced Corrosion MIC and its mitigation After reviewing the basics of corrosion it focuses on MIC MIC is a special type of electrochemical corrosion in which the presence of microbes and bacteria alters the chemistry of liquid media so as to make them more corrosive These changes are harmful to metallic equipment processing machinery marine vessels etc in an environment that is host to a wealth of microorganisms A 2007 US survey estimated corrosion related damages to cost 276 billion a year roughly 50% of which are due to MIC The industries most affected by MIC are power production oil exploration transportation and storage water distribution and more generally all industries involving marine environments However means for effectively preventing and controlling MIC are poorly understood As such the book s later chapters address various mechanisms processes that show promise with regard to MIC mitigation Lastly the book discusses the strategies currently being explored to mitigate MIC using green technologies

*Root Cause Failure Analysis* Trinath Sahoo, 2021-05-05 Root Cause Failure Analysis Provides the knowledge and failure analysis skills necessary for preventing and investigating process equipment failures Process equipment and piping systems are essential for plant availability and performance Regularly exposed to hazardous service conditions and damage mechanisms these critical plant assets can result in major failures if not effectively monitored and assessed potentially causing serious injuries and significant business losses When used proactively Root Cause Failure Analysis RCFA helps reliability engineers inspect the process equipment and piping system before any abnormal conditions occur RCFA is equally important after a failure happens it determines the impact of a failure helps control the resultant

damage and identifies the steps for preventing future problems Root Cause Failure Analysis A Guide to Improve Plant Reliability offers readers clear understanding of degradation mechanisms of process equipment and the concepts needed to perform industrial RCFA investigations This comprehensive resource describes the methodology of RCFA and provides multiple techniques and industry practices for identifying predicting and evaluating equipment failures Divided into two parts the text first introduces Root Cause Analysis explains the failure analysis process and discusses the management of both human and latent error The second part focuses on failure analysis of various components such as bolted joints mechanical seals steam traps gearboxes bearings couplings pumps and compressors This authoritative volume Illustrates how failures are associated with part integrity a complete system or the execution of an engineering process Describes how proper design operation and maintenance of the equipment help to enhance their reliability Covers analysis techniques and industry practices including 5 Why RCFA fault tree analysis Pareto charts and Ishikawa diagrams Features a detailed case study of process plant machinery and a chapter on proactive measures for avoiding failures Bridging the gap between engineering education and practical application Root Cause Failure Analysis A Guide to Improve Plant Reliability is an important reference and guide for industrial professionals including process plant engineers planning managers operation and maintenance engineers process designers chemical engineers and instrument engineers It is also a valuable text for researchers instructors and students in relevant areas of engineering and science

**Engine Company Fireground Operations** Raul Angulo, 2020-03-26 The National Fire Protection Association NFPA and Jones Bartlett Learning are pleased to bring you the fourth edition of Engine Company Fireground Operations This expanded edition incorporates the latest recommendations from UL and the National Institute of Standards and Technology NIST into every aspect of fire attack and ventilation and presents an extensive study of engine company fire ground operations This new edition is an ideal resource for fire service personnel preparing for promotion or studying for a civil service examination Firefighters and company officers will gain knowledge in fire science building construction and the effects of burning modern fuels that result in extreme fire behavior Specific features include Detailed illustrations that show the tactics and approaches described in each chapter Case studies of strategies and tactics that resulted in firefighter line of duty deaths as well as those that were successful incorporated into the recommended practices of engine company fire attack rescue and ventilation Detailed information on size up that applies risk management principles to the Value Time Size method which considers survivability profiling and threshold limits identifying problems selecting strategies and tactics developing a quick incident action plan and applying a functional accountability system for safety A significant emphasis on attacking residential and commercial basement fires A one of its kind chapter on fireground operations and responsibilities for company level high rise firefighting with special attention paid to fire behavior within high rise buildings In depth coverage of all the basic engine company responsibilities including Equipment Initial hose lays and water supplies The deployment of attack back up and exposure hose

linesRapid intervention teamsSearch and rescueMaster streamsFire protection systemsStandpipe operationsSalvage and overhaul

*Production Chemicals for the Oil and Gas Industry* Malcolm A. Kelland, 2014-03-13 This text discusses a wide variety of production chemicals used by the oil and gas industry for down hole and topside applications both onshore and offshore It reviews all past and present classes of production chemicals providing numerous difficult to obtain references Unlike other texts that focus on how products perform in the field this book focuses on the specific structures of chemicals that are known to deliver the required or desired performance Where known it also details the environmental aspects of the chemicals discussed and their success in the field

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