

A photograph of an oil and gas refinery at night. The scene is illuminated by artificial lights, highlighting the complex network of pipes, steel structures, and tall distillation columns. A large crane is visible in the upper right, and the sky is a deep blue. The foreground shows a large, yellow-painted steel structure, possibly a support for a pipeline or a walkway.

# **An Introduction to Asset Corrosion Management in the Oil and Gas Industry**

SECOND EDITION

**Ali Morshed**

# **An Introduction to Asset Corrosion Management in the Oil and Gas Industry**

(2nd Edition)

Dr. Ali Morshed



**NACE International**  
**The Worldwide Corrosion Authority**

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Printed in the United States of America

ISBN: 978-1-57590-338-5

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NACE International  
The Worldwide Corrosion Authority  
15835 Park Ten Place  
Houston, TX 77084  
[nace.org](http://nace.org)

# Contents

[Preface](#)

[Acknowledgments](#)

## **CHAPTER 1: INTRODUCTION**

[1.1 Background](#)

[1.2 Rationale](#)

[1.3 Scope](#)

## **CHAPTER 2: DEFINITIONS, ABBREVIATIONS AND ACRONYMS**

[2.1 Definitions](#)

[2.2 Abbreviations and Acronyms](#)

## **CHAPTER 3: THE CORROSION MANAGEMENT CONCEPT**

[3.1 Corrosion and Corrosion Failures in the Oil and Gas Industry](#)

[3.2 The Evolution of the Corrosion Management Concept Definition](#)

[3.3 The Integrity Management Measure](#)

[3.4 The Significance of the Integrity Review Process](#)

[3.5 Determination of the Management Requirements](#)

[3.6 Corrosion Management vs. Corrosion Engineering](#)

[3.7 Corrosion Management and Corrosion Engineering Interactions Post-Commissioning](#)

## **CHAPTER 4: THE CORROSION MANAGEMENT PROCESS AND IMPLEMENTATION**

[4.1 The Corrosion Management Process](#)

[4.2 The Integrity Review Process \(IRP\)](#)

[4.3 Monitoring Performance](#)

[4.4 Assessing Effectiveness](#)

[4.5 Corrosion Management Implementation](#)

## **CHAPTER 5: THE PRODUCTS OF THE CORROSION MANAGEMENT PROCESS**

[5.1 Corrosion Management Products](#)

[5.2 Mitigation Requirements Determination](#)

[5.3 CE-based Requirements Determination](#)

[5.4 Monitoring Requirements Determination](#)

[5.5 Management Requirements Definition](#)

[5.5.1 Registers](#)

[5.5.2 Strategies](#)

[5.5.3 Procedures](#)

[5.5.4 Databases](#)

[5.5.5 Documentation](#)

[5.5.6 Communication](#)

[5.5.7 Training and Competence](#)

[5.5.8 Corrosion Control Matrices \(CCM\)](#)

[5.5.9 Corrosion KPIs](#)

[5.5.10 Asset Corrosion Management Strategy \(Asset CMS\) Document](#)

[5.6 Determination of FRA Requirements](#)

## **CHAPTER 6: TYPICAL CORROSION MANAGEMENT SHORTCOMINGS**

[6.1 AIMS and the Integrity Review Process](#)

[6.2 Distinguishing Between Non-CE-based and CE-based Shortcomings](#)

[6.3 Non-CE-based Shortcomings](#)

[6.3.1 Shortcomings Associated with the Integrity Review Process](#)

[6.3.2 Shortcomings Associated with Regular Performance Monitoring](#)

[6.3.3 Shortcomings Associated with Assessing Effectiveness](#)

[6.3.4 Shortcomings Associated with Registers](#)

[6.3.5 Shortcomings Associated with Strategies](#)

[6.3.6 Shortcomings Associated with Procedures](#)

[6.3.7 Shortcomings Associated with Databases](#)

[6.3.8 Shortcomings Associated with Documentation](#)

[6.3.9 Shortcomings Associated with Communication](#)

[6.3.10 Shortcomings Associated with Training and Competence](#)

[6.3.11 Miscellaneous](#)

[6.4 CE-based Shortcomings](#)

[6.5 Possible Roots of Non-CE-based Shortcomings and the Proposed Solutions](#)

## **CHAPTER 7: CM APPLICATIONS BENEFITS**

[7.1 CM Application and Their Potential Benefits](#)

[7.2 Primary Benefits of Corrosion Management Applications](#)

[7.2.1 Determination of the Existing and Potential Integrity Threats](#)

[7.2.2 Devising the Required Mitigation or Remedial Activities](#)

[7.2.3 Improved \(Regular\) Performance Monitoring](#)

[7.2.4 Improved \(Regular\) Effectiveness Assessment](#)

[7.3 Secondary Benefits of Corrosion Management Applications](#)

[7.3.1 Improved Safety and Environmental Protection](#)

[7.3.2 An Improved Risk-based Approach to Inspection and Integrity](#)

[7.3.3 Optimized Chemical Treatment](#)

[7.3.4 Pre-empting Corrosion Failures and Leaks](#)

[7.3.5 Increasing Asset Uptime](#)

[7.3.6 Optimized Repair and Replacement Planning and Implementation](#)

[7.3.7 Optimized Integrity Management Costs](#)

[7.3.8 Enhanced Communication, Team Work and Performance](#)

[7.3.9 Improved Corrosion Rate and Fluid Monitoring](#)

## **CHAPTER 8: TAKING CM APPLICATIONS FURTHER**

[8.1 CM Applications for Downstream Oil and Gas and Other Industries](#)

[8.2 High-level Integrity Management KPIs](#)

[8.3 Integrity Management Contracts](#)

[8.3.1 Recommendations for Contract Terms](#)

[8.4 Integrity Management Software](#)

[8.5 Roles and Responsibilities](#)

[8.6 Codes and Standards](#)

[8.7 Management of Change](#)

## **CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS**

[9.1 Conclusions](#)

[9.2 Recommendations](#)

## **APPENDIX A—CORROSION MANAGEMENT CASE STUDIES**

## **INDEX**

# Preface

It has been more than six years since I submitted the first edition manuscript to NACE for publication. Since then I have had numerous opportunities, either as an engineer, a trainer, a consultant, or a university lecturer to get involved in various corrosion management projects, agenda, forums, and training courses.

Simultaneously, I have had the chance to do the above in many different countries and regions including the UK, North Africa, the Persian Gulf Region, and South Asia. Interestingly, the outcome and conclusion of most of the above involvements have been the same: Corrosion engineering by itself could not adequately, efficiently, and satisfactorily mitigate our corrosion problems and that corrosion management applications are simultaneously indispensable to do so.

In addition, I have witnessed numerous times how proper corrosion management applications have resulted in cost optimizations, enhanced chemical treatments, ‘real’ risk-based inspections, and improved (corrosion engineering and corrosion management) awareness and competencies.

It is this first-hand experience and involvement that has been keeping me excited about corrosion management applications and provided me with the driving force to press on with the second edition of this book.

As with the first book, I have tried to keep this new edition as simple, clear, and practical as possible. I have incorporated improvements in the following areas:

1. The definition of the corrosion management concept has been further revised to render it clearer and easier to both understand and implement ([Chapter 3](#)).
2. A new, useful concept in the form of the ‘integrity (management) measure’ has been added to further distinguish the corrosion management concept and applications from those of the corrosion engineering ([Chapter 3](#)).
3. [Figure 4.2](#) has been totally revised and extended, making it easier for any reader or potential corrosion management practitioner to better appreciate the various components of the corrosion management model presented in the book. Actually, [Figure 4.2](#) should be regarded as the ‘heart’ of this book. The parameters listed under the ‘non-corrosion-engineering-based integrity management measures’ box are those for which misinterpretation or wrong or inadequate implementation often leads to the majority of corrosion problems in the Oil and Gas Industry and beyond ([Chapter 4](#)).
4. Implementation guidelines have been added to [Chapter 4](#) (Corrosion Management Process and Implementation) for facilitating step-by-step corrosion management applications.
5. Case studies have been added to further illustrate how the corrosion management process and applications could be used to:
  - Better identify and determine (both the corrosion engineering-based and the non-corrosion engineering-based) shortcomings that often cause corrosion problems.
  - Illustrate how some of the existing, acute, and costly corrosion issues have roots in

# 1

## Introduction

### 1.1 Background

Corrosion is a ubiquitous and deleterious natural phenomenon that affects our lives on a daily basis. It deteriorates and causes damage to various metals in not only our home appliances, automobiles, airplanes, and ships, but also to various utilities (water, gas, and electricity), public buildings, highway bridges, pipelines, and oil and gas assets.

Perhaps nothing could better highlight and demonstrate the effect of corrosion on our society and day-to-day life than the following excerpts from the study carried out by the American Federal Highway Administration, completed in 20021:

- The annual direct cost of metallic corrosion in the US was \$276 billion.
- This figure represented 3.1% of the US Gross Domestic Product (GDP) and was equal to a direct corrosion cost of just under \$1,000 per person per year.
- The total direct and indirect corrosion costs were \$552 billion or 6% of the GDP.

In the oil and gas industry, where corrosion is a major integrity threat, the figures were similarly remarkable. The direct corrosion costs for the oil and gas exploration and production sector was \$1.4 billion. The figure for the petroleum refining sector was \$3.7 billion.<sup>1</sup>

Corrosion costs in the oil and gas industry could be due to, but are not limited to:

- Higher number of equipment failures
- Lower (personnel) safety and environmental protection levels
- Higher repair and replacement costs and high stock levels
- Increased plant downtime and deferred production
- Higher insurance premiums

To combat and control corrosion and its consequences in the oil and gas industry and to reduce costs, corrosion engineering has been used as the main tool and discipline so far. For many assets (such as offshore platforms, onshore processing plants and refineries, and pipelines and petrochemical complexes), corrosion engineering-oriented asset integrity management systems (AIMS) are created to facilitate and promote effective corrosion combat and mitigation.

An appropriate corrosion engineering input during an asset's design stage can significantly improve the overall asset integrity management post-commissioning. Once an asset has been commissioned, such input and applications should be reviewed as (and when) required to ascertain that they remain relevant, adequate, and effective. However, as an asset ages, likely operational and process changes may render the incumbent corrosion engineering applications less relevant, up-to-date, and efficient. This could lead to a situation where the asset suffers from many corrosion-related problems with increasing number and severity, if such changes (and their potential effects on an asset's integrity) are



not addressed in a timely and proper manner.

However, working with and studying various integrity management projects has demonstrated that corrosion engineering by itself cannot effectively and efficiently mitigate corrosion post-commissioning. Numerous observations have revealed that many corrosion-related failures, leaks, and near misses are not at all due to obsolete, inadequate, or erroneous corrosion engineering designs and applications, but they were promoted, accelerated, and bolstered by some other shortcomings. These observations also highlighted other factors or parameters (by their absence or inadequate presence and application due to negligence, ignorance, complacency, and/or incompetence) that could adversely influence an asset's overall integrity management.

The following list identifies some cases where such non-corrosion engineering parameters or factors were believed to be the main integrity culprits:

- The most prevalent deterioration mechanisms behind a majority of observed regular equipment leaks and failures—in an asset or within a particular system—were not identified over long post-commissioning periods. The failure to do so often led to an inability to devise and implement required remedial, corrective, or rectifying activity (or activities).
- No integrity reviews were carried out post-commissioning, when some changes in the operations and process parameters had increased corrosion threat levels or even created new ones. This situation often led to higher deterioration rates and more frequent leaks, equipment failures, and near misses.
- Lack of appropriate and much-needed databases, registers, procedures, strategies, meeting minutes, and other forms of documentation containing data, information, guidelines, and instructions that could have significantly improved an incumbent asset integrity management system
- Lack of adequate communication between various individuals or companies who contributed to the overall asset integrity management
- Lack of adequate training, not only in corrosion engineering, but also in corrosion management
- Reliance on out-of-date, inaccurate or irrelevant data, and information that often led to erroneous technical judgements and decisions with seemingly higher cost implications
- A non-risk-based approach to inspection and overall asset-integrity management

With the benefit of hindsight, many of the above issues and shortcomings (which had led to various corrosion failures) could have been easily and conveniently prevented and mitigated if a simple but well-defined and multi-staged process had been in place. This process would have included the following three stages:

1. Review the required integrity management measures
2. Monitor their performance regularly
3. Assess their effectiveness

Simultaneously, assets that had used this process benefited greatly from significantly better asset integrity management associated with optimized costs.

This book is all about this process, which is referred to as (Asset) Corrosion Management. Its main recommendations include that an AIMS should include two main components: corrosion engineering and corrosion management. This book is almost entirely dedicated to the latter component, its process, products, applications, and benefits.

## **1.2 Rationale**

The perceived lack of appreciation for the corrosion management concept, process, applications, and benefits was the main incentive behind this book. The book is also based on observed improvements in overall asset integrity management for assets where the corrosion management process had been introduced and applied (in particular, for more mature assets). Such benefits (i.e., improvements in asset integrity management) were often associated with enhanced personnel safety, environmental protection, and cost optimizations.

It is strongly believed that many similar improvements and benefits can be accomplished if such corrosion management know-how, experience, and expertise were shared with others in the oil and gas industry.

There are already some positive signs, such as an increased emphasis by many operators and contractors to move toward risk-based inspections, maintenance, and integrity management systems. This illustrates the corrosion management process and its useful applications (e.g., risk-based inspections) were gaining more acceptance and recognition among operators and integrity contractors alike.

Nevertheless, it is also believed that many operators and (integrity) contractors are still oblivious of the corrosion management concept and its applications. This was made evident by many integrity management shortcomings and failures—from the lack or inadequate application of the corrosion management process—observed during various site visits.

This book has been written for both of the above groups, with the main aim being to produce a useful and practical tool, and a source of guidelines in the field of corrosion management in the upstream offshore sector and beyond.

Last but not least, the author first started teaching and providing training in this topic starting in 2005. As he became more involved with international integrity management projects, he wrote articles about this topic in the NACE International MP Journal, beginning in 2007. The positive and encouraging feedback he has received after each MP article is one of the main reasons and incentives behind this book.

## **1.3 Scope**

The author has written this book mainly using his experience in the offshore oil and gas industry sector. However, the discussions, guidelines, and principles in this book are (in the majority of cases) both simple and general. As such, they can be used or applied—with slight changes or modifications

where necessary—to all types of oil and gas assets including:

- Offshore platforms and their associated subsea infield and transfer pipelines
- Onshore processing plants and refineries and their associated transfer and export pipelines
- Petrochemical complexes

Furthermore, it is believed that the corrosion management principles discussed in this book can prove to be useful in other industries where corrosion is also a major integrity issue. Some slight changes or modifications may be necessary for designing corrosion management applications or implementing the applications in industries outside of the oil and gas industries.

# 2

## Definitions, Abbreviations and Acronyms

Corrosion and integrity engineers are believed to be the main discipline with interest in this book. Nevertheless, this book is also intended for other disciplines that often assist the corrosion engineer with mitigating corrosion and managing the asset integrity. Such disciplines may include:

- Inspection technicians and engineers
- Integrity project engineers and managers
- Technical assistants
- Chemical suppliers (or the chemists)
- Pipeline integrity engineers
- Maintenance engineers
- Microbiologists
- Reliability engineers

Due to such diversity, some of the aforementioned disciplines may not be fully or adequately conversant with some of the corrosion management-related terminology used in this book. This chapter provides definitions for some of the main terms and concepts used throughout this book.

Of paramount importance is the definition offered for the term *risk-based inspection* (RBI). RBI is probably the most common term, used in the field of (pressure systems) integrity management. In spite of its wide use, there appears to be a lack of consensus about its meaning and applications, as different users may mean different things with the term. This often leads to further confusion and misunderstanding, especially when negotiating and signing integrity management contracts for pressure systems and equipment.

Another good example is the term *corrosion management*, which is the main theme of this book. To many corrosion engineers, this term is still—unfortunately—regarded as a synonym for corrosion engineering. However, corrosion management should be regarded as an independent concept with its own definition, scope, and applications.

As such, all the terms used in this book are based on the definitions offered in this chapter, unless otherwise stated. Furthermore, this chapter includes some terms that are believed to be misnomers and are not used in this book at all (they are included here to discourage their further use). A good example of this is the term ‘corrosion risk assessment’ (CRA), which is used by some as a synonym for FRA, but that conveys the wrong message, as explained later.

### 2.1 Definitions

The following definitions apply to the terms as they are used in this book.

**Anomaly:** A feature, item, or part of the pressure equipment or peripherals that detracts from original