

Corrosion Risk Assessment of Aging Plant in the Down Stream Petroleum Sector

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ABSTRACT

Equipment and Piping failures present the greatest risk to the integrity of metallic components in down-stream petroleum sector. The implementation of Mechanical Integrity (MI) systems in the downstream petroleum sector differs based on the interpretation of various Industry standards, etc. Despite implementation of MI system, failures leading to loss of containment (LOC) are ubiquitous in aging plants. Robust and effective corrosion assessment requires focused effort from many disciplines within the organization to ensure that threats and monitoring regime are fully, identified, understood, and managed.

Corrosion risk assessment is an effective tool for screening, assessing, and managing threat at the segment and sub-segment level. Consequently, effective equipment and piping segmentation based on fluid corrosivity is paramount towards initiating corrosion-risk assessment or risk-based inspection (RBA/RBI) program. Corrosion assessment allows a review of inspection and operation data to review barriers and mitigations to ensure safe operations in accordance with the design intent. Corrosion risk management is undertaken through the following key steps; threat identification, risk assessment, risk response and risk review. This continuous, cyclical process is required to ensure that all risks are appropriately mitigated or managed.

This paper shares experiences and challenges of corrosion risk assessment in the down-stream petroleum industries and simplify ways of managing corrosion through effective corrosion assessment regime.

Key words: corrosion risk assessment (CRA), risk-based assessment (RBA), risk-based inspection (RBI), mechanical integrity (MI), corrosion under insulation (CUI), piping segmentation (Corrosion Loops), stress corrosion cracking (SCC), chloride (Cl) potential damage mechanism (PDM), as low as reasonably practicable (ALARP).

INTRODUCTION

Many refineries and petrochemical plants are operating well beyond their original design life. Consequently, operating these plants beyond their design life presents safety and business risks as well as operational challenges. The mechanical integrity of equipment and piping of these plants presents enormous challenges in maintaining plant integrity and reliability. Implementation of rigorous corrosion risk assessment (CRA) is required to ensure all degradation mechanisms associated with aging are identified, understood and mitigation developed to reduce the risk. Some of the degradation mechanisms are listed in Table 1 below; a sample table containing some PDMs:¹

Table 1: A Table of Some PDMs

PDM	PDM
General Corrosion	Corrosion Under insulation (CUI)
Localised Corrosion	Chloride Pitting
Galvanic Corrosion	Microbiologically Influenced Corrosion (MIC)
Crevice Corrosion	Brittle Fracture
Erosion	Stress-Oriented Hydrogen Induced Cracking (SOHIC)
Cavitation	Creep
Thermal Fatigue	Atmospheric Corrosion

CRA, RBI or RBA serves as an integral part of corrosion management strategy. CRAs provides vital integrity evaluation of condition of equipment and piping based on inspection report and operation data. Major integrity decisions such as shutdowns, equipment replacement or upgrade are undertaken after CRAs. The risk of failure leading to loss of containment underscores the importance of accurate data for corrosion risk assessment.

The intent of this paper is to share industry experience in carrying out CRA in aging plants; this will help to provide understanding of the integrity assurance measures required to be implemented; it provides steps towards undertaking a systematic corrosion risk assessment. Major goals of CRAs is corrosion management through the implementation of the following measures:

- Identifying unit corrosion threats
- Evaluation of the risk posed by the corrosion threat
- Develop mitigation measures to reduce the effect of corrosion threats to As Low As Reasonably Practicable (ALARP) levels

Evaluation of capital equipment such as vessels, columns, overhead condensers and waste heat boilers is a herculean task that requires critical analysis to enable management make decision with cost implication in terms of safety and production.

CORROSION RISK ASSESSMENT APPROACH

CRA is a semi quantitative technique of evaluating equipment and piping integrity with respect to potential damage mechanism (PDM), it allows for the estimation of corrosion rates, equipment and piping remaining life by analyzing potential damage mechanism vis-a-vis operating parameters, the consequence of failure drives the risk in CRAs, this also determines the type and nature of implementation mitigation plan.

A successful CRA is achieved by team of expertise comprising cross-functional teams such as corrosion, process, inspection, RBI and operation engineers in its implementation. The analysis helps

management to make an informed decision to prevent the occurrence of a potential failure resulting in high consequence in terms of safety, environmental impact, production losses as well as damage of reputation. CRA output also influences modification or replacement strategy and provide vital input in turn-around planning, facilitates the determination of the necessary mitigation and monitoring which include the nature and location of the most significant risks to the equipment and piping.² Figure 1 shows the approach to conduct CRA; a good CRA will enhance or drive an excellent corrosion management strategy and will require varying degree of skills including:²

- Detail understanding of process streams
- An in-depth knowledge and understanding of potential damage mechanism of each stream
- Comprehension of all operation, monitoring, inspection and maintenance limitation
- Following an optimum sequential approach as shown in Figure1

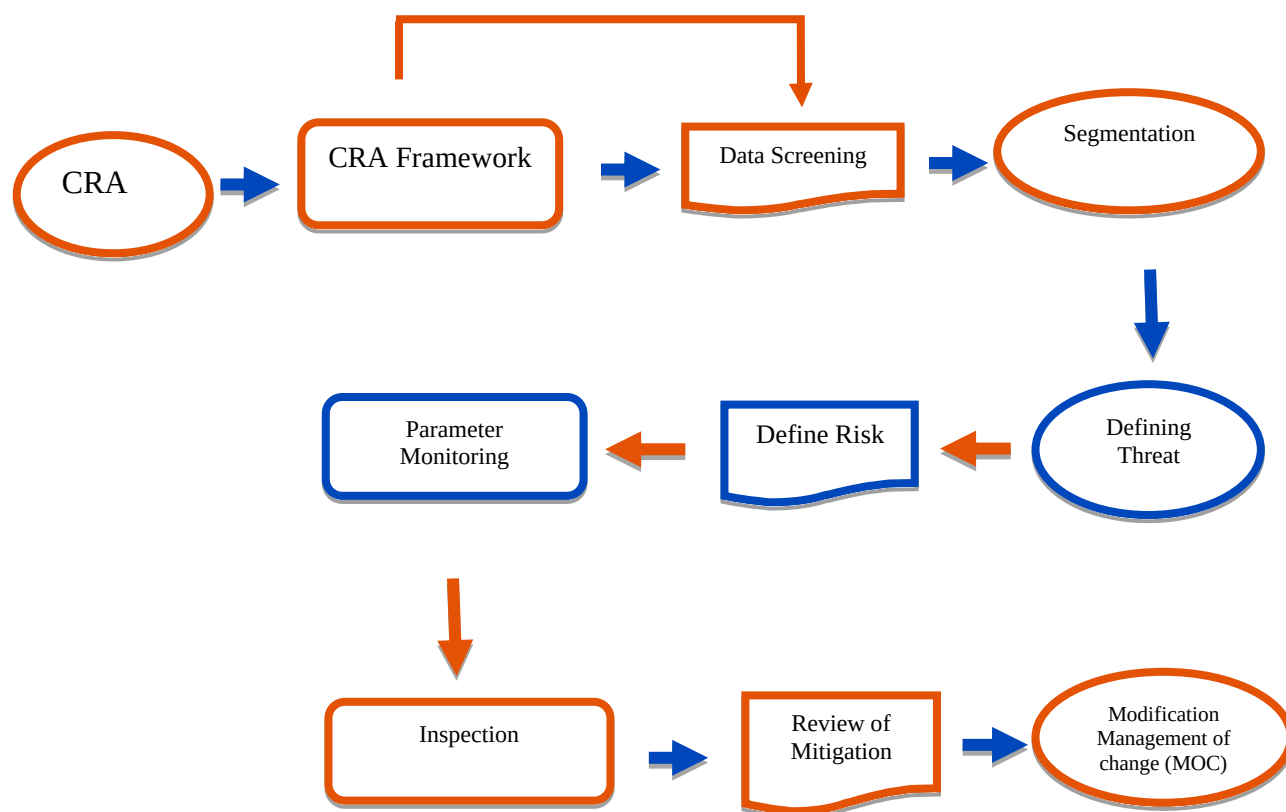


Figure 1: Block Diagram of Corrosion Risk Assessment

CRA identifies the location-specific of events and/or conditions that could lead to equipment and piping failure and provides an understanding of the likelihood and consequences of an event². CRA can be conducted at the segment level or equipment level and should be conducted when new corrosion threat is observed.

Design and Operating Data

This is the first step to conduct corrosion risk assessment, and involves data collection, review, and integration of relevant data and information that is needed to understand the condition of the equipment and piping; identify the location-specific threats to equipment integrity; and understand the potential impact on environment, safety and operational consequences of an incident. The types of data to

support a risk assessment will vary depending on the threat being assessed. Information on the operation, maintenance, patrolling, design, operating history, and specific failures and concerns that are unique to each system and segment are required to conduct CRA.

Corrosion Risk Assessment should be based on system design as detailed in the latest available project documentation at the time of the risk assessment; this includes drawings, documentation and Management of Change (MOCs). The source of data should be documented, and uncertainties highlighted.

The quality of data are to be reviewed especially in case of missing or large uncertainties in the data. During operational phase, a more accurate data needs to be gathered, e.g. through additional inspections, monitoring and testing. Conservative assumptions are sometimes utilized for risk assessment, especially when gaps in data or uncertainties in the data accuracy are suspected. The following design and operating details are the sources for data input into CRA:

- Design considerations such as galvanic coupling, dead legs, crevices, and bends.
- Design codes and standards
- Material Selection diagrams (MSDs), Piping & Instrument Diagrams (P&IDs), Built in Isometric Drawings and Process Flow Diagrams (PFDs)
- Vessel general arrangement; detail drawings & Corrosion loops if available
- Piping specification and line list (line numbers, line class, specification, operating and design temperature and pressure conditions)
- Protective coatings, cladding and insulation type and extent
- Anticipated deterioration mechanisms (rates and severity what is/are the consideration in the material selection reports)
- Inspection records (eg schedules, frequency, extent, methods, technique and efficiency), Isometric drawings (construction and/or inspection Isometric)
- Monitoring records (probes, coupons, bio probes etc.)
- Permanent and temporary repairs (e.g. spool replacement records, wraps, clamps etc.)
- Failure records and Maintenance history (e.g. Actual plant failure frequency data, industry benchmark, specific plant and equipment data)
- The established control limit of the stream and all analysis report including contaminants or trace components (e.g. Cl, CO₂, H₂S, Moisture, pH, scaling, Sulphate Reducing Bacteria (SRB), General Heterotrophic Bacteria (GHB) and Nitrate Reducing Bacteria (NRB) etc) are reviewed during CRA
- Corrosion rates (known and predicted) and Corrosion monitoring program as Chemical injection program

Segmentation (Corrosion Loops / Circuits)

Refineries and petrochemical companies consist of large number of piping and equipment. Consequently, it is impractical to perform any meaningful corrosion assessment for each equipment and piping, and therefore, an efficient corrosion assessment demands grouping of these piping and equipment into systems and subsystem; of same process stream, same material and same potential damage mechanism (PDM) this is termed as corrosion loops/circuit. The main elements in corrosion loop is the loop description, boundaries, corrosion rates and corrosion parameters such as pH, CO₂, Cl etc.. Corrosion loops provide a quick and simplified way of evaluating corrosion in corrosion control program. Figure 2 shows simple corrosion loops process and a schematic of corrosion loop.