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RISK ASSESSMENT TOOL FOR CORROSION MANAGEMENT – A BOON OR BURDEN

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ABSTRACT

A risk assessment is a common tool employed by Operators during different stages of an asset's life cycle, and can be used to varying degrees of depth and detail. With newer oil and gas fields being developed in deeper water and harsher operating conditions corrosion management has become a growing challenge. In case of brown fields, extending life of existing fields by addition of new wells poses its own unique challenge for demonstrating fitness for purpose. A well implemented risk assessment should allow identification, review of operational conditions, and mitigation of credible corrosion degradation mechanisms to prevent any catastrophic failures. However, there are challenges in the application of risk assessments and translation of results into a robust plan for active management and continual improvement of ongoing corrosion management based on results of inspection and monitoring activities.

This paper discusses lessons from a decade of risk assessment application in effective corrosion risk management for offshore oil and gas fields. Case studies are presented to demonstrate effective use of risk assessment to support the ability to manage human involvement factor, risk management strategy updates to support changes in operational parameters, and chemicals management with respect to incompatibility of chemicals and role of monitoring. Finally, a few recommendations are offered with an aim to evaluate and improve existing corrosion risk management practices through effective use of risk assessment as a tool for Operators.

Key words: Corrosion, KPI, Risk Assessment.

INTRODUCTION

Corrosion management is a significant piece of the overall asset wide integrity management puzzle. Maintaining or extending life of brown field assets or newer green field developments in deeper and harsher operating conditions both poses unique challenges with internal and external corrosion management. It is therefore very important to establish a strong link between data gathered and applicable degradation mechanisms. Operators also need to be able to demonstrate that the risk assessment and resulting risk management activities are being implemented in an effective and appropriate manner. Risk assessment is a commonly adopted tool in the industry; however, there is a constant battle between the effort versus value in implementation of risk assessment process.

Risk assessment output depends on the ability to determine existing condition of the equipment with respect to desired performance based on design. Risk is increased when there is no data or low confidence in the key data required to assess the corrosion risk and vice versa. Key data comes from equipment design criteria, fabrication details, operation procedures, Key Performance Indicator (KPI) monitoring, inspection findings, industry knowledge, historical information, and associated anomalies. This information also helps to identify the corrosion deterioration mechanisms and the rate at which deterioration may progress thereby enabling an effective fit for purpose assessment. Inspections and monitoring can then be planned at appropriate intervals using methods that are able to detect the type and level of corrosion anticipated. The written scheme of corrosion control plan focuses finite inspection resources to the equipment within the system with greatest corrosion concern. Corrosion risk changes with time either because the physical changes in equipment condition, or because new information becomes available. The risk assessment highlights the importance of feedback and the re-assessment of corrosion risk on periodic basis along the different stages of equipment lifecycle. A typical risk assessment process is shown in Figure 1.

The objective of this paper is to share lessons from application of risk assessment in corrosion risk management and provide guidance to help evaluate and improve existing corrosion risk assessment process.

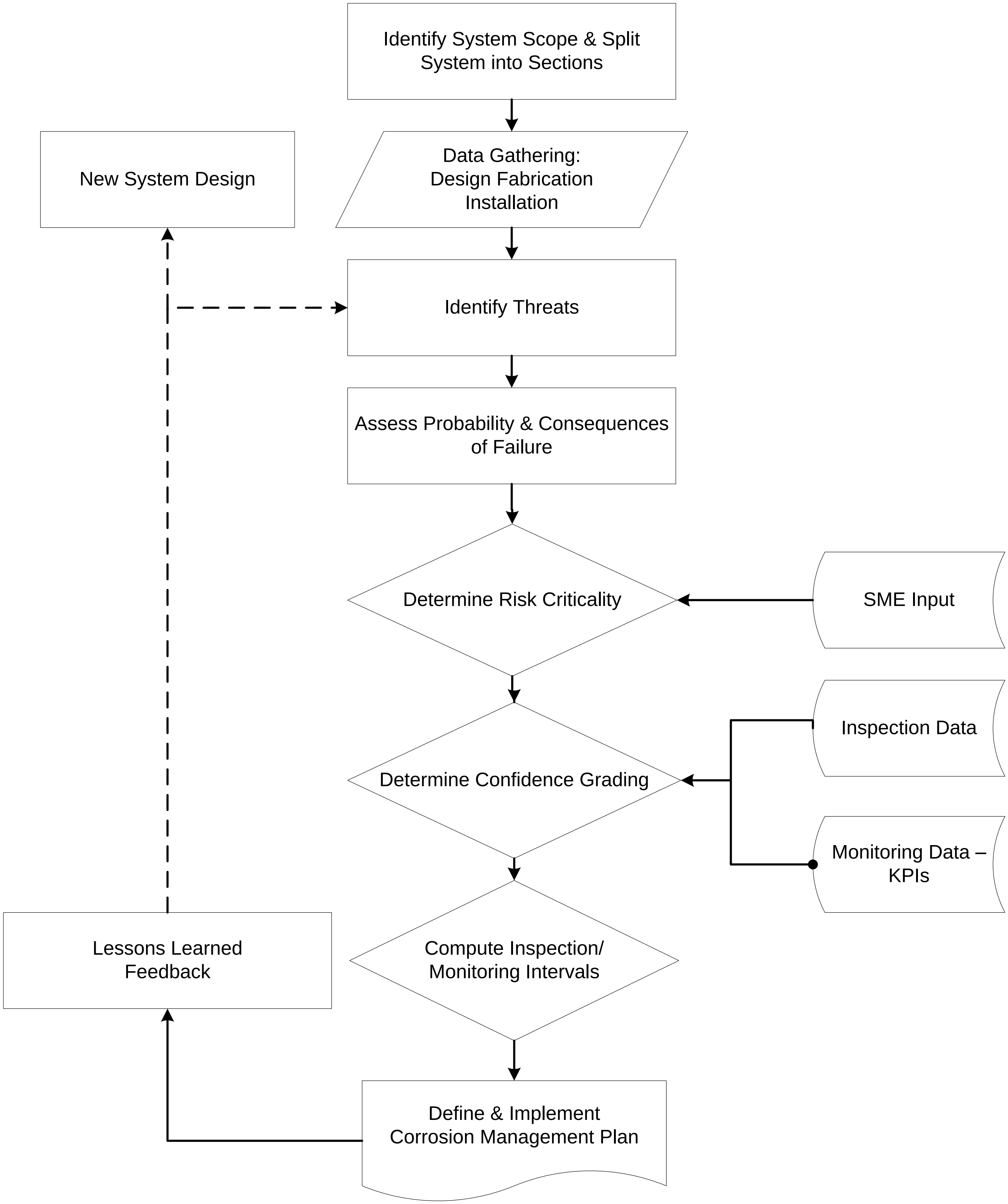

Figure 1: Corrosion Risk Assessment Methodology [1] [2]

LESSONS LEARNED

A risk assessment is a tool that helps develop corrosion integrity management plan and requires continual updates based on new operational integrity data gathered through implementation of risk based recommendations, i.e. monitoring and inspections. A Bow Tie diagram serves as a good basis in evaluation of risks associated with internal and external corrosion. A typical bow tie diagram is shown below in Figure 2. A bow tie approach facilitates evaluation of internal and external corrosion barriers applicable to system under consideration and associated risk consequences for a given risk event. A non-exhaustive list of typical barriers, barrier validation methods, and potential mitigation options are listed in Table 1 for reference.

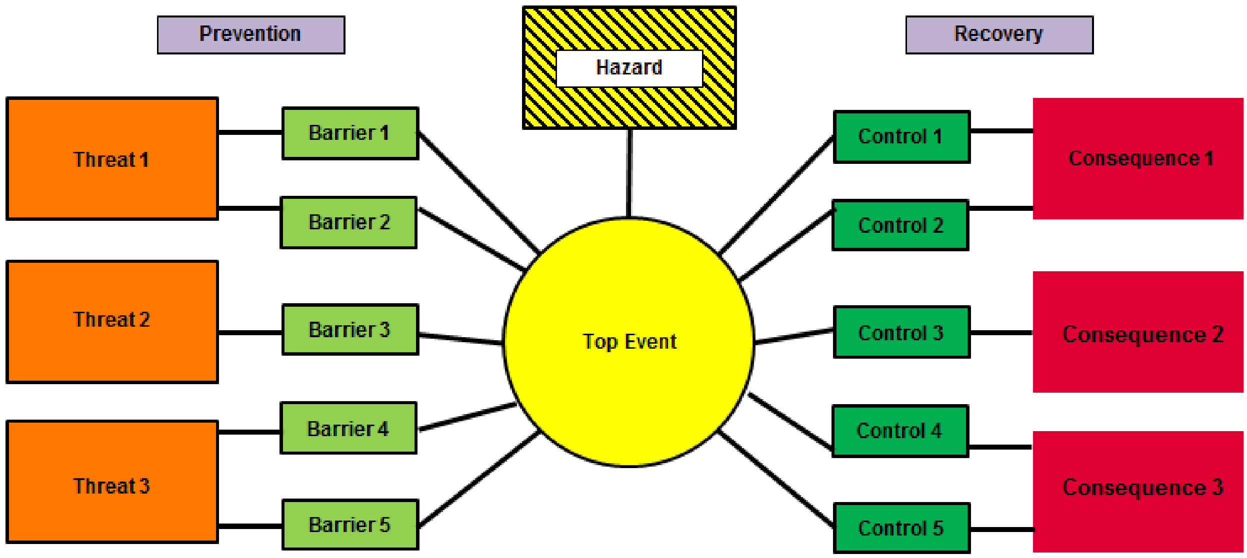

Figure 2: Bow-Tie Diagram Example

	External Corrosion	Internal Corrosion
Barriers	• Material Selection • Design • Coatings • Cathodic Protection • Corrosion Allowance	• Material Selection • Design • Chemical Treatment • Corrosion Allowance • Operational Procedures
Validation of Barriers (Monitoring/Inspections)	• Cathodic potential measurements • GVI surveys • NDE • Anode Decay	• Corrosion Probes & Coupons • Residual corrosion inhibitor testing • CI dosage monitoring • Chemical compatibility testing • Corrosion Modeling • Pig trash analysis • ILI • NDE
Mitigations / Solutions	• Anode retrofit • Coating Repair • Equipment Replacement	• Maintenance pigging • Dead leg management • Chemical Replacement • Equipment Replacement

Table 1: Barriers & Validation – External and Internal Corrosion [3]

One of the key factors in successful corrosion management program is involvement of key stakeholders in risk assessment and identification of relevant recommendations for managing risks including identification of type and intervals of mitigations, monitoring, and inspections. This ensures effective implementation and gathering relevant and quality data that helps improve understanding and management of degradation mechanisms. Different groups within the organisation and third party vendors may be responsible to manage day to day corrosion management activities. Communication is hence crucial in achieving desired outcome for risk management. Typical stages involved in development and implementation of corrosion management plan and associated stakeholders are shown in Figure 3.

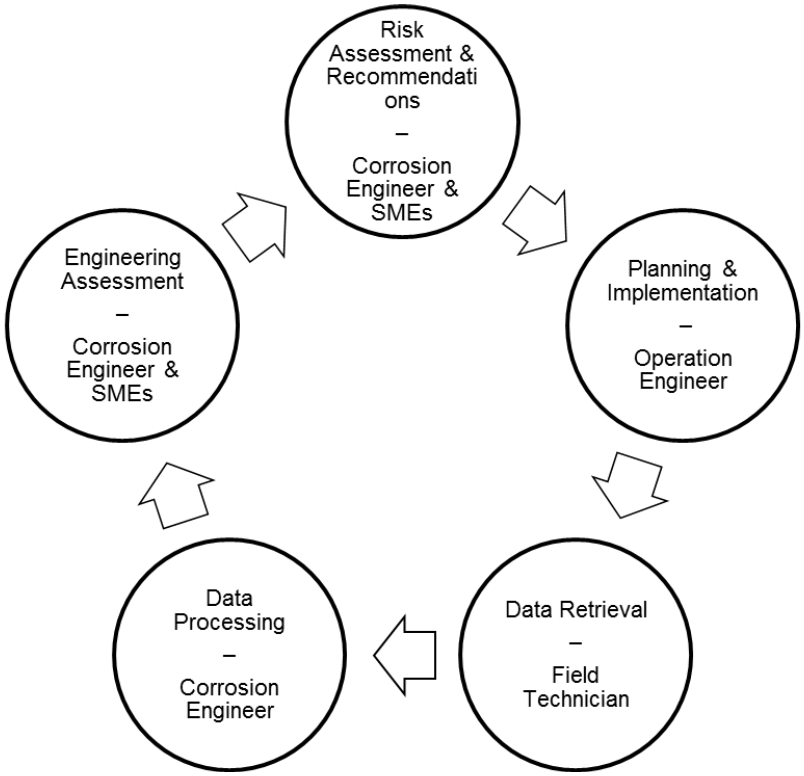

Figure 3: An Example of Corrosion Management Plan and Stakeholder Responsibilities

A few example case studies are discussed herewith demonstrating the effective use of risk assessment and key lessons learned to maximize the value for effective corrosion management.

Case Study 1 – Data Relevance & Validation

Does the monitoring data on your system reflect the true performance of the barriers and provide leading indications of failure mechanism?

Internal corrosion monitoring requires understanding of the fluid flow patterns. This is very crucial since flow pattern helps identify the corrosion mechanism as well as location along the pipe circumference where worst corrosion rate is expected. For example, for stratified flow, highest corrosion rate is expected to occur on bottom section of the line, especially if water separation occurs as shown in Figure 4. Therefore, internal corrosion rate monitoring via corrosion coupons is considered accurate and effective when coupon is in contact with the production fluid (i.e. located bottom of line) in this case. Corrosion monitoring results from coupons located at top/middle of line will not reflect the true risk of the corrosion. This type of issue may go unnoticed if there is no structured data assessment process in place to identify such discrepancies.

Lessons Learned

Appropriate inspection and monitoring intervals should hence be identified so as to allow timely and periodic evaluation of data collected and risk management activities that help identify potential ineffectiveness and offer an ability to improve or replace risk management activities to gather relevant and quality data.

A sensor/monitoring location map should be created for the asset to provide clarity and auditable record that promotes periodic assessment and verification of data retrieval sources.

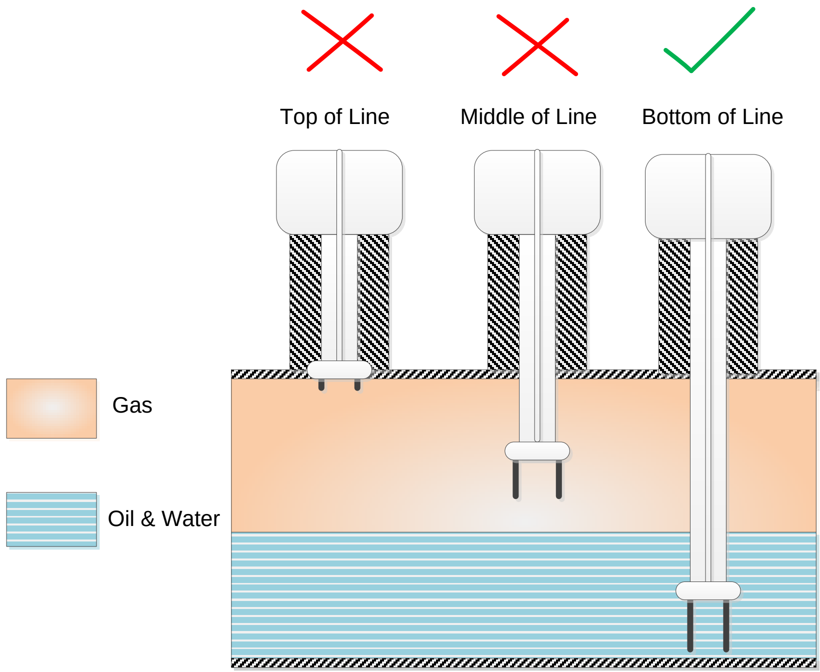

Figure 4: Corrosion Coupon Location – Stratified Flow

Case Study 2 – Manage Human Error Factor

Does your risk assessment process allow you to identify monitoring data reporting discrepancies potentially due to human error?

Human involvement is evident in performing day to day corrosion management activities and there is always possibility of error in performing or interpreting assigned task irrespective of level of training and motivation within responsible person. However, the consequences of such human error can potentially be catastrophic. In order to manage human error proactively it should be addressed as part of the risk assessment process via validation and quality assurance of data retrieved.

This example discusses incorrect reporting of water cut monitoring data from producing well by Field Technician. This water cut data feeds into the corrosion program where corrosion inhibitor dosage to control the corrosion gets calculated. As a consequence of incorrect input of water cut number, corrosion inhibitor dosage level and thereby corrosion rates are different than desired resulting in incorrect interpretation of risk levels as shown in Figure 5. Under dosage of corrosion inhibitor as result of low water cut data reporting (incorrect data) may lead to increased probability of internal corrosion and associated failure risk if this issue goes unnoticed for a long period.

Lessons Learned

Detailed written schemes of examination for inspections and monitoring should be developed that clearly identify data sources and requirements, quality checks, sensor locations, and reporting requirements. This allows an effective engineering assessment of data gathered, offers an auditable track record to identify errors in data collection, and promotes ability to update and improve procedures based on observed inaccuracies.

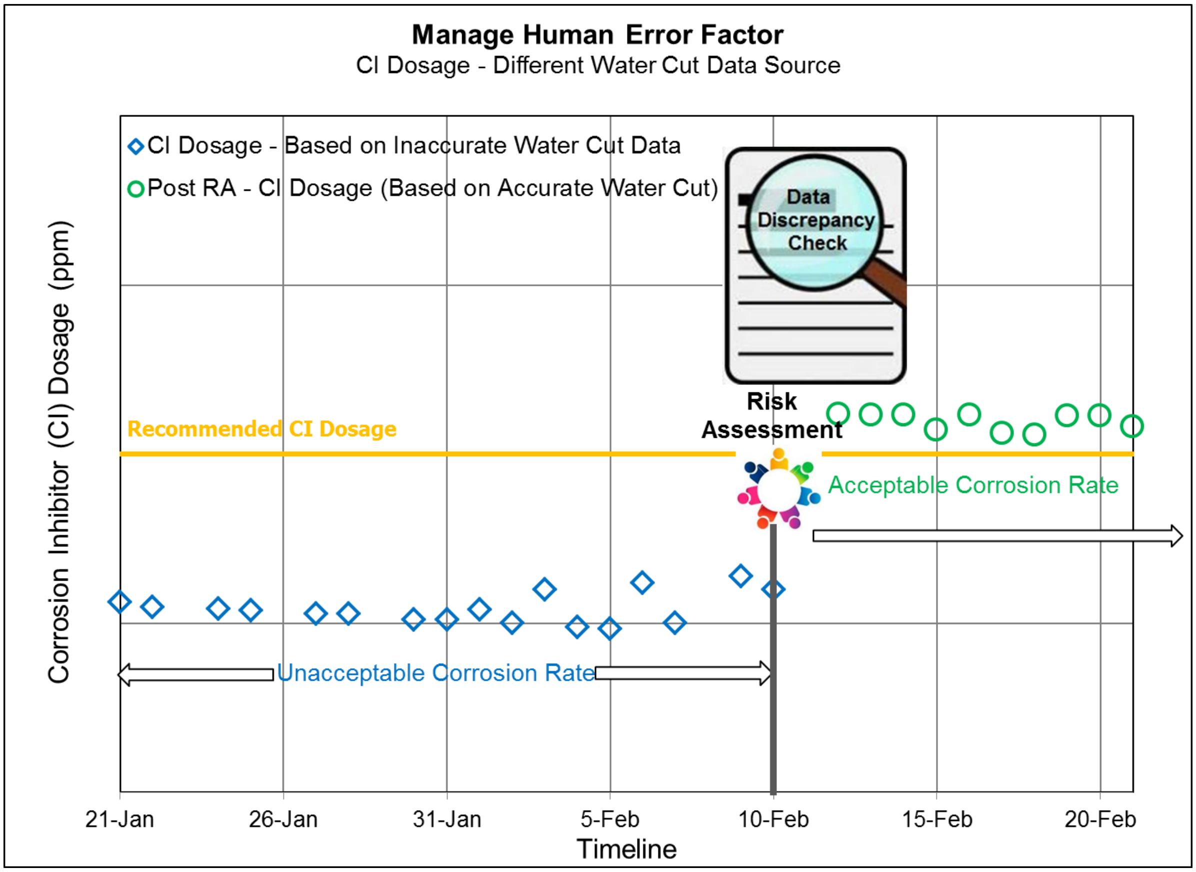

Figure 5: Human Involvement Factor – Identify Discrepancies

Case Study 3 – Anode Retrofit Based on Degrading CP Trend

Does your risk assessment process reflect the condition of the corrosion control barriers and their effectiveness? Does the risk assessment allow altering data retrieval intervals based on barrier conditions?

External corrosion risk on offshore production risers is controlled via installation of sacrificial anodes to provide required cathodic current for protection. In this example a baseline risk assessment is performed on the newly installed production riser to evaluate the external corrosion risks and consequently CP inspection interval of 3 years is determined with a baseline CP survey required in the first year after installation which identifies acceptable CP levels. A CP survey 3 years after baseline acceptable CP survey has identified degradation in the CP system and consequently risk of external corrosion is re-visited through the risk assessment process. This reduced CP performance resulted in a lower annual CP survey to closely monitor CP performance to confirm the level of CP degradation. The trend of CP degradation is confirmed to escalate during the annual CP survey and consequent risk re-evaluation concluded that the consumption rate of sacrificial anodes is higher compared to design predictions. Therefore, recommendation was made to install a retrofit anode sled at the base of the riser for provision of adequate CP current to meet the remaining life of the risers. Example of degrading trend of cathodic potentials over time is shown in Figure 6.

Lessons Learned

Risk based prioritization of the CP inspections allowed to capture the degrading cathodic potentials on the riser system before riser potential dropped down to the free corrosion potential.

Leading indications of degrading CP system allowed enough time to perform engineering review of CP design, design of retrofit anode sled, fabrication and procurement, systems integration test activities, and installation thereby avoiding any unplanned shutdown of the system.

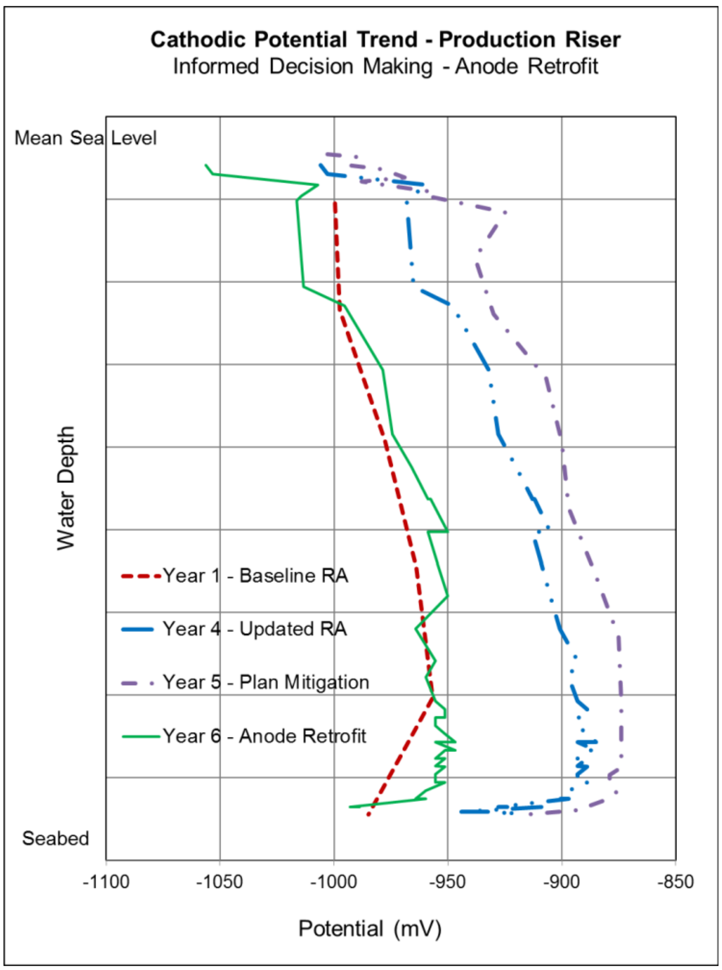

Figure 6: Cathodic Potential Degradation – Anode Retrofit

VALUE OF CORROSION RISK ASSESSMENT

Development and effective implementation of risk assessment process can offer tremendous value in corrosion risk management throughout asset lifecycle.

Development of Corrosion management Strategy – FEED Stage

Risk assessment during the Front End Engineering Design (FEED) stage taking into consideration applicable corrosion threats to the system allows development of a relevant Corrosion Management Strategy (CMS) that will define required action plan to mitigate and control corrosion risks and identification of Key Performance Indicators (KPIs) to monitor the effectiveness of corrosion management activities. CMS can be an input to the design phase of the system in terms of identifying the design modifications to accommodate the CMS requirements. Additionally, relevant inspection and monitoring solutions can be evaluated and defined to improve data relevance, use of appropriate technology thereby helping develop a coherent plan for corrosion management.

Educational Process

Risk assessment process offers value in terms of educating all stakeholders on condition of the system and provides a central platform with respect to historical and current corrosion performance of the system. Risk assessment tool should offer the ability to completely understand the system information via data gathering from different stages of equipment life such as design, fabrication, installation, and operations.

Gap Identification

Available data from the design, fabrication, installation, and operation phase of the equipment is gathered in process of corrosion risk assessment. This exercise allows identification of the data gaps which are required to be addressed in order to perform effective risk assessment and replacement of assumptions if any, with actual data.

Structured risk assessment process also helps identify the gaps in technology and challenges in application of technology to particular equipment to gather the required corrosion data. This information becomes valuable feedback for future designs and in development of new technology to address existing data gathering challenges.

Prioritization of Inspection, Maintenance, and Repair (IMR) Plan

Risk assessment process determines the risk level of applicable corrosion threats. This process allows developing corrosion management plan and prioritizing activities based on the risk level.

This risk based approach to define inspection intervals allows avoiding repetitive inspection or maintenance activities on equipment that has been assessed as low risk and efforts are directed towards management of higher risks. This process reduces operational costs via optimization of activities. An example of maximum inspection intervals based on the corrosion risk on the risk matrix is shown in Table 2.

Risk Matrix		Consequence				
		1 Extreme	2 High	3 Medium	4 Low	5 Negligible
Probability	A Frequent					
	B Occasional					
	C Possible					
	D Unlikely					
	E Improbable					

Immediate Frequent Less Frequent Occasional

Table 2: Example – Risk Based Intervals

Asset Life Extension Process

Corrosion is a time dependent process and ability to trend and determine corrosion risk levels is vital in verification and ability to determine life extension of ageing assets. Availability of the corrosion risk assessment results throughout the life cycle of the asset under consideration provides a strong platform to make informed and confident decisions to run, repair, or replace equipment in support of life extension objectives.

Periodic Reviews

The risk assessment can only reflect the condition of the system at a given time when the input data was collected. The risk assessment process is dynamic and therefore corrosion risk levels will keep changing through the life of equipment based on changes in operational philosophy and conditions, age, inspection and maintenance activities, and engineering assessment of results. Re-assessment of the corrosion risk should therefore be undertaken at relevant stages of the asset life cycle. Periodic re-assessment allows ability to link data to degradation mechanisms and maintain risk management plan relevant to asset condition.

CONCLUSIONS

Operators have traditionally followed a prescriptive inspection approach to control the corrosion. Trend toward the life extension of brown fields demand a risk based approach towards the corrosion risk to determine the fitness for purpose. Risk assessment enables the Operator to understand credible corrosion degradation mechanisms of the system and make informed and confident decisions to manage the corrosion risks. Risk based approach allows to manage the likelihood of corrosion failure at an acceptable level and subsequently avoid the failure consequences to health and safety, environment, financial, and business reputation risks. The risk assessment delivers optimized operations through proactive and prioritized corrosion risk management, cost optimization, and an auditable corrosion condition history of an asset.

In order to ensure successful and effective implementation of risk assessment to manage corrosion, it is recommended to implement below listed tasks:

- Review existing inspection and monitoring techniques to confirm their capability to detect and evaluate identified corrosion mechanism through risk assessment;
- Validate monitoring and inspection data accuracy and relevance;
- Involve all stakeholders in the risk assessment process in order to implement risk assessment recommended actions as intended;
- Periodically re-assess risk assessments to reflect the changes in operating conditions or physical equipment condition and thereby incorporate required alterations to risk management activities;
- Input from subject matter experts is crucial to determine the corrosion risk and identification of corrosion control actions; specifically if data trends and historical failure data is not accessible;
- Feedback lessons learned while performing risk assessment and implementing corrosion control activities into the existing process and into the new system design to minimize corrosion risks.

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