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Improvement of Oil and Petrochemical Processing by Performance of Corrosion Integrity Management

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Abstract

One of the most important tasks to eliminate risks and dangers in oil and petrochemical plants is the prevention of corrosion. This implies the provision of safe enclosures and reaction spaces for the substances to be processed. Application of corrosion control methods is not enough, while some strategies to be followed strictly to minimize corrosion risks. Such as deals with the procedure in the selection of materials for equipment exposed to corrosion and stresses the difficulties connected with the elimination of corrosion. Installation of high sophisticated and experienced systems is emphasized. The main objective of a corrosion management system is to minimize the loss of containment of hydrocarbon and other critical non hydrocarbons which can be directly attributed to corrosion and which have a detrimental impact on operation of process plants. Corrosion management also helps in making accurate inspection plans and optimizing the inspection intervals. A corrosion management system is a part of the overall integrity management program that integrates various corrosion control methods to achieve mechanical integrity and reliability of static equipment/piping. It deals with the understanding, identification, measurement, monitoring, control and mitigation of different corrosion mechanisms within the process plants. Root cause analysis (RCA) and risk based inspection (RBI) are a part of the essential components of such corrosion management system. This paper will focus the importance of corrosion management system in oil and gas sector and how it can minimize the loss produced by corrosion phenomena.

Keywords: Corrosion management; corrosion monitoring; corrosion control.

1. Introduction

Corrosion management has been defined as the part of the overall management system that develops, implements, reviews and maintains the corrosion management policy and strategy and includes a clear set of corrosion management system requirements that can, and should, be considered normative. All oil and petrochemical asset are susceptible to corrosion should have an asset corrosion management system with corrosion engineering and corrosion management components to protect it against dangers that could produces as result of corrosion phenomena. Many assets lack an up-to- date and functional asset corrosion management system with a corrosion engineering component largely because of a lack of understanding of the corrosion management concept and its confusion with corrosion engineering. To rectify this situation, oil and petrochemical assets can be divided into various groups based on their corrosion management system requirements. Thereafter, remedial actions can be under taken for each group to improve the integrity situation in general and the asset corrosion management system in particular. Implementation of asset corrosion management system will provide full information to the asset owner about integrity, cost, time and reliability benefits. The management of corrosion should be not considered only during operation of the production facilities but during the design and commissioning stage in planning and construction limits to corrosion risk as well.

2. Corrosion Overview

Corrosion is a naturally occurring phenomena commonly defined as the deterioration of metals or its properties due to its reaction with its environment. Modern corrosion science has its roots in electrochemistry and metallurgy. Whereas electrochemistry contributes to the understanding of materials via corrosion, metallurgy provides information about the behavior of the material and their alloys hence provide a medium for combating the degradation on them. The corrosion mechanism and its rate depend on the nature and aggressiveness of environment (air, soil, water, etc.) in which the corrosion takes place, which is a function of meteorological and pollution parameters. The existence of anodic cathodic sites on the surface of a piece of metal implies that the difference in electrical potential is found on the surface. This potential difference has the tendency of initiating corrosion. The metallic surface exposed to an aqueous electrolyte usually possesses site for oxidation (anodic reaction) that produces electrons in the metal and reduction (cathodic reaction) that consumes the electrons produced by the anodic reaction. These sites make up a corrosion cell.

3. Corrosion Economics

Corrosion is technical and economic problem, but a relatively small of data of corrosion cost and corrosion economics is available. Such information requires a very hard work to collect a real and actual data due the both of complex measures and variety of the sources. However, the estimated annual cost of corrosion worldwide is exceeding 2.2 trillion US dollars, which translates to 3 – 4 percent of the GDP of industrialized countries. Earlier studies of cost of corrosion revealed that approximately a third of these annual costs could be saved if the existing corrosion prevention and control knowledge would be applied. Corrosion Costs and Preventive Strategies in the United States, backed by the U.S. Federal Highway Administration, estimated annual costs at the time of $276 billion-approximately 3.1% of the nation's Gross Domestic Product (GDP). Research shows that between 1980 and 2006, 50% of European, major hazards of loss containment events arising from technical plants failures was primarily due to ageing plants mechanism caused by corrosion, erosion, and fatigue.

4. Corrosion Management

A very common definition of Asset Integrity Management reads as follows: "Asset Integrity is the ability of an asset to perform its required function effectively and efficiently while safeguarding life and the environment. Management activities ensure that the people, systems, processes and resources which deliver integrity, are in place, in use and fit for purpose over the whole lifecycle of the asset". A very common definition of Corrosion Management reads as follows:" Corrosion management is that part of the overall management system, which is concerned with the development, implementation, review and maintenance of the corrosion policy". The most common approach to improve asset corrosion management is to perform an integrity review and use its various products to create or update an asset corrosion management which is classified as one of the most important components of any integrated asset corrosion management system. Figures 4.1 and 4.2 showed the structure of asset integrity management and corrosion management components.

Figure 4.1: Asset integrity management Structure

All oil, gas and petrochemical asset are susceptible to corrosion and therefore they requires active corrosion management program. This program is concluded of many processes such as reviewing the applied corrosion management considerations, the regular monitoring of their performance, and the assessment of their effectiveness post-commissioning. Figure 4.3 illustrates the scope of corrosion management system.

Figure 4.4 is a Venn diagram which represents a precise definition and distinct between corrosion

Figure 4.2: Corrosion management Structure

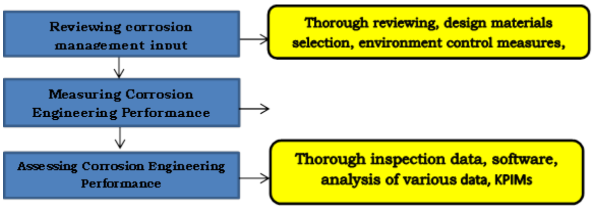

Figure 4.3: The scope of corrosion management process

management and corrosion control and provides right figures for improved performance of engineering systems by preventing unplanned shutdowns or sudden failures. The primary corrosion mechanism includes general corrosion , galvanic corrosion , localized corrosion , fretting and flow induced corrosion. The secondary corrosion mechanism includes theses effects by contributions from the people , influences of a remote subsystems and unpredictability of environment such as changes in atmospheric condition.

5. Importance of Corrosion Management

The implementation of an integrated corrosion management program has a direct effect on the assets overall economic performance of both direct and indirect costs and elimination of corrosion related damage/deterioration of assets as well. An effective online integrated corrosion monitoring system allows facility high management to take immediate corrective actions before costly or catastrophic

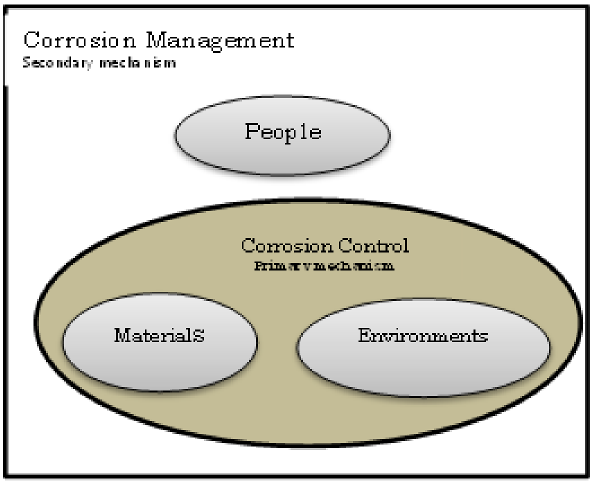

Figure 4.4: Venn diagram illustrates the relationship between corrosion management, corrosion control, materials, environments and people

failure keeping facility and operators in safe situation minimizing the risk of failure. It is also classified precisely the operating equipment to the different levels of risk according to its operation parameters and history material integrity reducing the cost of inspection intervals and time consumption. In addition, it is a simple matter to generate Key Performance Indicators (KPIs) of the organization such as the cost of corrosion and performance levels of corrosion control techniques. In general, corrosion management contributes to numerous benefits such as reduction in leaks, increased plant availability, and reduced unplanned maintenance, reduction in deferment costs and corporate compliance with safety, health and environment policies.

6. Corrosion Management Techniques

The corrosion management consists of many interconnected stages. It provides basic measures for risk determination through planning, implementation, and control strategies. To manage corrosion involves the utilization of a framework that will model the organization's policy through organizing, implementing, monitoring and analysis the obtained data, comparing to the control criteria and auditing performance. The general view of corrosion framework is shown in Figure 6.1.
The following is the most important assessment and techniques used for corrosion severity determination whereas the risk of failure is expected:

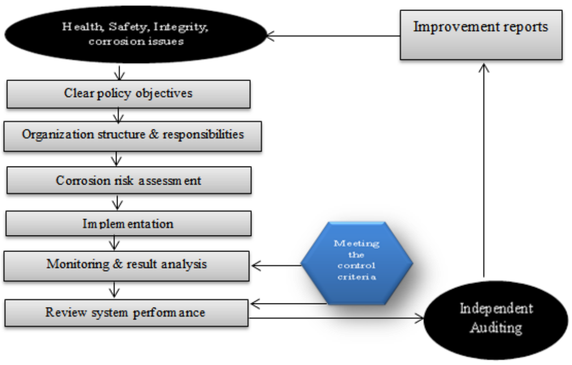

Figure 6.1: Corrosion management framework

6.1. Advanced Inspection Technologies

Advanced inspection technologies offer many improvements over traditional nondestructive test methods providing more accurate assessments, reducing maintenance costs and ensure reliable operating processes. These technologies has also become an important inspection tool for minor defect detection and supporting the risk assessment analysis and risk based inspection to confirm assets reliability and avoided sudden failure. Here some of these technologies:

- Guided wave testing for screening changes in material properties due to corrosion or cracking around the circumference.
- Pulsed eddy-Current (PEC) for detection of corrosion under Insulation.
- Acoustic emission for detect defects and flaws even at early stages.
- Corrosion mapping is an ultrasonic technique by using an automatic or semi-automatic scanner to identify variations in material thickness due to corrosion.
- Automated ultrasonic phased array testing and time of flight diffraction for detecting flaws efficiently and welding quality.
- Computed radiography for precise imaging with greater picture enhancement.

6.2. Risk Based Inspection (RBI)

RBI technique is used to develop an optimum plan for the inspection activities in oil and petrochemical industries. A risk-based approach to inspection planning will ensure that risk is reduced to the low reasonably practicable. It will also optimize inspection schedule, focus effort on the most critical equipment according to its operation parameters, case history and expected nature of corrosion minimizing the inspection intervals and cost impact accordingly. Planning a risk-based analysis involves listing activities, identifying the technical and potential risks and reduction actions to be followed by authorized people. API 580: RBI is a risk assessment and management process that is focused on loss of containment of pressurized equipment due to material deterioration. Risk categories (higher, medium and lower) may be assigned to the boxes on the risk matrix as shown in the figure 6.2

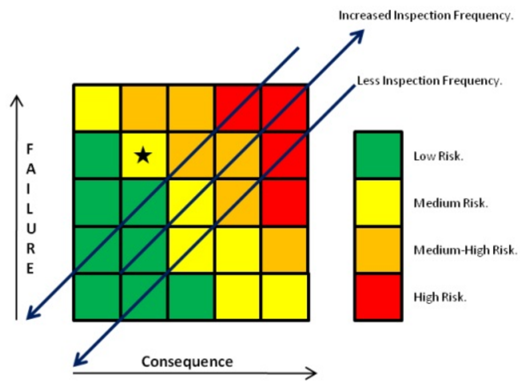

Figure 6.2: Likelihood of failure 1 to 5 [$m10^{-n}$ leak/year] /Consequence A to E [sq. damage area] Risk Rank (Low, Medium or High) / Inspection priority = Risk Rank

6.3. Corrosion Risk Assessment (CRA)

The main aim of corrosion risk assessment is to classified the equipment according to their susceptibility to corrosion and identify the best methods for mitigation. Corrosion risk assessment (CRA) is a key part of any corrosion management scheme, using likely corrosion threats and potential corrosion locations to provide a statement on the condition of the equipment. The corrosion risk assessment includes a compilation of all relevant equipment data related to the basic design, operation, inspection and maintenance and provides any information regarding previous repairs. It is possible through CRA, to estimate the corrosion rates and the remaining life by using available operational parameters such as CO_2, H_2S, temperature, pressure, flow rate, and standard models.

6.4. Corrosion Monitoring

Late detecting of corrosion can be costly and may lead to assets catastrophic failures. Effective corrosion monitoring program is ensuring the equipment integrity are maintained and corrosion mitigated during facility operation. A thorough practice for corrosion management involves the monitoring of corrosion risks through proactive and reactive monitoring techniques. In-line system covers the installation of devices directly into the pipeline like corrosion coupons and they need to be removed for corrosion rate calculations. On-line monitoring techniques include installation of devices directly fixed into the process such as electrical resistance probes, linear polarization resistance probes, fixed ultrasonic probes and acoustic emission. A good corrosion monitoring system is an investment in improved economy extended asset life and safer operations.

6.4.1. Internal Corrosion Assessment

Internal corrosion of pipes and pressure vessels can be measured using corrosion monitoring devices such as electrical resistance probes, linear polarization probes, weight loss coupons and traditional non-destructive techniques. Intelligent or smart pigs are used to internal the pipelines to perform various operations without stopping the flow of product. One of these applications is inspection of surface pitting, corrosion, cracks and weld defects in steel pipes by using Magnetic flux leakage pig (MFL) and providing a location specific defect map and characterization which will facilitate the proactive plan for repair such defects before any leakage.

6.4.2. External Corrosion Assessment

External corrosion direct assessment (ECDA) is a structural process that is intended to improve safety by assessing and reducing the impact of external corrosion on pipeline integrity. As explained in NACE standard practice SP-0502-2008. The direct current voltage gradient (DCVG) technique and close interval potential survey (CIPS) technique are the most used techniques for the pipelines assessment.

6.5. Corrosion Control Techniques

Corrosion can be controlled by means of understanding the principle of corrosion mechanism. Selection of cost-effective methods to control corrosion and successful implementation of methods identifying opportunities for further development and improvement is one of important steps of corrosion management strategies. The main aim of corrosion management is to make balance of financial and technical requirements. During the design stage, a proper material selection as one of important corrosion control methods to be considered on basis of balance between CAPEX and OPEX requirements. This is applicable for implementation of appropriate mitigation techniques during other stages as well. Standard procedures and practices for achieving effective of corrosion mitigation are well established by application of industrial coatings, cathodic protection and corrosion inhibitors. Occasionally, combination of two techniques is used such as in protection of piping and steel tanks whereas the cathodic protection system and coating are used. A good selection of corrosion inhibitors is still the best method of preventing internal corrosion of equipment while the material selection is important factor for corrosion protection as preliminary action of safe equipment operation.

7. Conclusion and Recommendations

In front of high risks and economics impact of corrosion phenomena in oil and petrochemical industries, it highlights the urgent need to pay more attention of change the concept of corrosion resistance by more effective techniques such as installation of corrosion management system as a part of overall Assets Integrity Management system. Better corrosion management can be achieved using preventive strategies in in various complex process industries such oil and petrochemical industries. These preventive strategies include:

- Increase awareness of large corrosion costs and potential savings through application of sound corrosion management system.
- Change the misconception that nothing can be done about corrosion.
- Improve corrosion mitigation strategies by replacement of error-prone human decisions with proven and sophisticated technology.
- Monitor performance of corrosion management system on a regular basis.
- Close follow up of corrosion rates by effective computerize corrosion monitoring program.
- Implementation of assessment such as RBI and RCA.

- Considering of advance corrosion control methodology especially during design, construction stages.
- More awareness of advanced corrosion inspection techniques and updated codes and standards.

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