PLANNING AN OPTIMUM SYSTEM FOR OFFSHORE FACILITY CORROSION MANAGEMENT: SALMAN OFFSHIRE PLATFORM CORROSION MANAGEMENT IMPLEMENTATION CASE STUDY RESULT

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ABSTRACT

Corrosion is a naturally occurring phenomenon commonly defined as the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment. According to the current U.S. corrosion study, the direct cost of metallic corrosion is $276 billion on an annual basis. This represents 3.1% of the U.S. Gross Domestic Product. Facilities due to corrosive environment of water suffer corrosion. 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 corrosion policy provides a structured framework for identification of risks associated with corrosion, and the development and operation of suitable risk control measures. A general corrosion management system has been outlined that provides a progressive framework that is compatible with the requirements of an offshore safety management system concerned with ensuring the integrity of topside processing equipment. In this paper best practicable method for offshore facility corrosion management was suggested.

1. INTRODUCTION

Corrosion is a naturally occurring phenomenon commonly defined as the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment. According to the current U.S. corrosion study, the direct cost of metallic corrosion is $276 billion on an annual basis. This represents 3.1% of the U.S. Gross Domestic Product. Corrosion is the primary factor affecting the longevity and reliability of facilities that withdraw and transport crucial energy sources throughout the world. The average annual corrosion-related cost is estimated at $7 billion to monitor, replace, and maintain these assets. The corrosion-related cost of operation and maintenance makes up 80% of this cost. [1]

Offshore facilities like platform, pipelines have most problems with corrosion issue due to corrosive environment (water) and material (oil and gas) that operate with them. For decades, corrosion professionals have made great strides in developing cutting-edge technologies, employing effective management practices, and increasing public awareness about the critical need for corrosion control worldwide. The U.S. corrosion cost study has determined, however, that incorporating the latest corrosion control strategies still requires widespread changes in industry management and government policies as well as additional advances in science and technology. [1] Each of these methods is asset specific depending on factors such as:

- Design
- Stage in life cycle
- Process conditions
- Operational history

The success of any corrosion management system is reliant upon auditing and measurement of performance. Audit and measurement activities also contribute feedback ensuring continuous improvement in corrosion management activities. To assist in these activities this document contains checklists for self-assessment of corrosion management systems. Within this document corrosion management is defined as:

"**Corrosion management is that part of the overall management system, which is concerned with the development, implementation, review and maintenance of the corrosion policy**." [2]

A general corrosion management system has been outlined that provides a progressive framework that is compatible with the requirements of an offshore safety management system concerned with ensuring the integrity of topside processing equipment. That is, employers should have effective plans and organizations to control, monitor and review preventative and protective measures to secure the health and safety of employees.

2. Why Manage Corrosion?

It is widely recognized within the oil and gas industry that effective management of corrosion will contribute towards achieving the following benefits: [3]

• Statutory or Corporate compliance with Safety, Health and Environmental policies
• Reduction in leaks
• Increased plant availability
• Reduction in unplanned maintenance
• Reduction in deferment costs

The current statutory regime applicable to UK offshore oil and gas processing facilities places a requirement on the duty holder to maintain the integrity of the facilities, and to ensure that equipment can be operated safely and a safe working environment maintained. Loss of hydrocarbon containment on offshore processing facilities due to corrosion can result in severe consequences upon safety, the environment and asset value.

An analysis of data on offshore hydrocarbon releases reported by industry ranks corrosion as the second most frequent initiating factor leading to a loss of containment.[3] Failures of joints and flanges rank most frequent. Predicting the rate of plant degradation due to corrosion carries an element of uncertainty. Uncertainty can be reduced by corrosion management systems that combine both proactive and reactive management measures. There is an existing recognition by the UK Oil & Gas Industry of both the costs borne by their business that can be attributed to inadequate corrosion control, and the consequential impact upon operations. (figure1)

DIRECT COSTS	INDIRECT COSTS
Inspection Chemical inhibition Corrosion monitoring Coating maintenance	Increased maintenance Deferred production Plant non-availability Logistics

Figure1
Costs, direct and indirect

The effect, therefore, of implementing appropriate Corrosion Management Systems, that result in the reduction/elimination of corrosion related Damage/deterioration of assets, not only assists in compliance with regulatory /Requirements but also has a direct effect on the assets overall economic Performance, i.e. providing a "double pay back". [4]

3. Structured Framework for Corrosion Management

In the operation of an offshore oil & gas facility, the management of corrosion lies within the function of many parts of the duty holder's organization and increasingly extends into contractor organizations. It is therefore important that corrosion management activities are carried out within a structured framework that is visible, understood by all parties and where roles and responsibilities are clearly defined.

The key elements of such a framework, based on an existing HSE model are illustrated in Figure 2. [3]

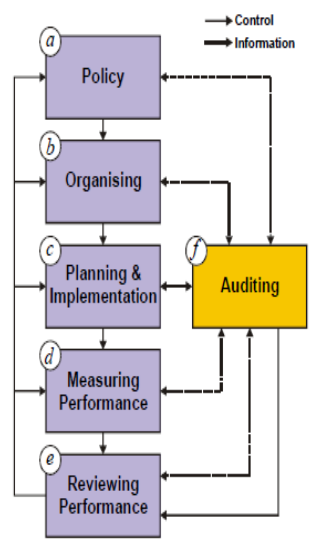

Figure2
Framework for Successful Corrosion Management
[3]

The overall policies adopted by an organization
The role and responsibilities of managers and staff within the organization, including the development and maintenance of appropriate strategies.
The development of plans and procedures, plus the means of implementation of various corrosion control measures.
The methods adopted for performance measurement of the system against pre-determined criteria.
The use of systematic and regular reviews of system performance.
The use of periodic audits of the management and monitoring systems.
In this paper all parts have been explained.

3.1 Policy & Strategy

A policy is a directive that specifies how a major operational issue should be handled over the longer term. It forms a basis for subsequent detail in terms of strategies, organization structures, performance standards, procedures and other managerial processes [3]. The corrosion strategy is the method by which the policy is implemented. (figure3).

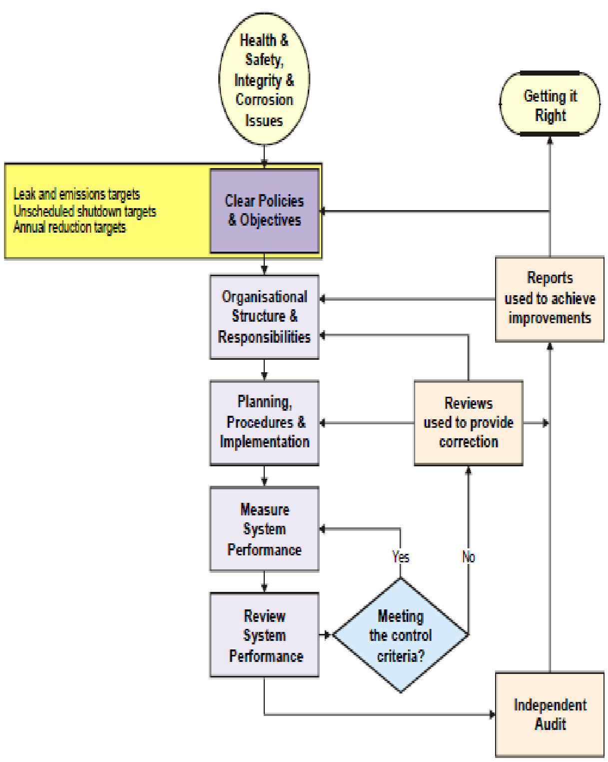

Figure3
Setting the policy [3]

All organizations should have in place policies and strategies that deal with hazards and risks associated with safety, health and environmental concerns. Thus, although many companies may not have a stated corrosion policy, all accept the inherent concept of good corrosion management practice is implied and is incorporated into their planning process. [5] Development of strategies for corrosion management involves many managerial and technical functions and impacts upon various levels within the duty holder and its contractors/sub-contractors [4]. Of most importance are:

• Overall management of corrosion risks
• Effective deployment of human resources
• Development of appropriate organizational structures
• Systems to meet changing situations

One successful approach to development of corrosion policy and strategy is the "link step approach" as shown in Figure 4. Inputs into the Review of External Factors include Safety, Economics and Operation. Strategy inputs are from a corrosion risk analysis that then results in a corrosion control matrix and roles and responsibilities for implementation [3].

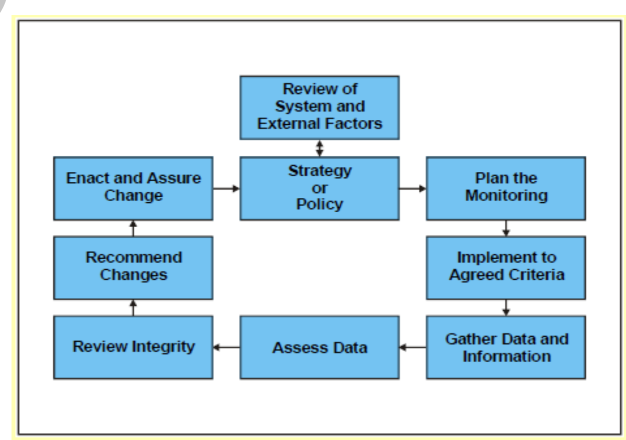

Figure4
Management Support of Offshore Safety Case [3]

It should be noted that a clear company policy statement, that provides guidance to the corrosion strategies to be adopted to ensure integrity, indicates senior management commitment and ensures that the correct corporate culture is established.

3.2 Organization

Effectiveness of any policy depends on the leadership, commitment and involvement of managers and senior staff. Safety is of concern to everyone; employer, employee and contractor. Corrosion should also be of similar concern. A positive "health and safety culture" and "corrosion culture" means less risk to individuals and less damage to the integrity of a facility. For organizing corrosion management the four “Cs” of a positive culture are [6]:

• Control
• Communication
• Competence
• Co-operation

Consideration of the four Cs is vital, particularly for management of complex multi-disciplinary areas, like corrosion management, which may well involve nonspecialist engineers. The issue of competence across the corrosion management structure is also important. The actual implementation, in particular the inspection activity, is well described by various national and international standards and codes-of-practice.

However, there are at present no equivalent requirements for the setting of the corrosion management plan, for data analysis, for the interpretation of results or for providing recommendations for corrective action. Most operators & contractors will appoint suitably experienced and qualified corrosion and/or materials engineers either to supervise or to carry out this activity, but there is no uniformity in the level of experience or qualification required. In addition to the need for personnel to have technical skills appropriate to the role, experience, expertise, knowledge and understanding of the area for which they are responsible is necessary along with behavioral skills relating to, for example, appropriate attention to detail, interpersonal skills and problem solving abilities. The level of skill, experience and expertise will vary depending upon the duties and responsibilities.

Once the necessary skills, expertise and experience for each role have been defined, ongoing assessment of personnel can be beneficial. This ensures that the competence of individuals is appropriate, and is a method by which requirements for implementation of further training, for example, may be identified [7]. An important aspect is to ensure that offshore personnel are fully committed and involved in the corrosion management process, and that corrosion is not seen as just an "onshore support" activity.

3.3 Planning & Implementation

This section includes the methods and key elements of planning and implementation, which forms the largest single part of any corrosion management process. The purpose being to ensure that the activities within the corrosion management strategy are carried out in a logical order in an efficient way that is fully auditable. Without planning the implementation of strategies becomes confused, diffuse, and likely to fail. Planning and implementation covers both the collection of data relating to the condition and corrosion risk of the facility as well as the operation of the corrosion control / corrosion engineering activities required to ensure that deterioration is eliminated / minimized.

This includes risk assessment, monitoring and inspection procedures, data collection / analysis and correction actions to control corrosion. Planning and Implementation constantly and rapidly influence one another through the internal flow of information. This constant "self regulation" works within the overall framework.

3.3.1 Existing Assets or New Build

The detail for implementation of corrosion management plans may differ significantly between new build facilities or assets and existing or ageing systems [8]. New build provides an opportunity to incorporate all appropriate current best practice from concept stage through asset or field life. The requirement to systematically and continuously plan and implement an appropriate corrosion management system remains constant.

3.3.1.1 New Build - Inherent Safety

In addition to the specific legislative requirements, the planning process should encourage control of risks using the concept of inherent safety. The principles of inherent safety are more effective at the concept stage and detailed design stages. However, the same approach should be applied during operations when Modifications and repairs are considered (design-out maintenance).

Figure5
A new Offshore Platform (BP Company, North Sea)

3.3.1.2 Existing Infrastructure

One major factor that will impact on the corrosion management planning and implementation stage is planned asset life. Corrosion management planning should be based on the long-term corporate strategies and objectives for the production facility and therefore the corrosion risks need to be appraised against these objectives when planning and implementing corrosion control activities to meet the required asset life [3].

As technology advances asset life expectancy is increasingly being extended beyond originally designed time-scales. It is, therefore, important when planning to extend field life beyond design limits to be able to accurately gauge corrosion control status. Life extension may well require re-appraisal of corrosion risks and major changes to planned activities.

3.3.1.3 General

Identification of hazards, assessment of risks and agreement on planned activities is a fundamental requirement of the management process. Planning and implementation often makes use of company guidelines, industry codes and international standards. Checks are also needed to determine whether they are appropriate and effective for each particular asset. The ownership of actions and responsibilities relating to the corrosion management plan are vital to successful operation.

As part of this process the duty holder should keep appropriate records of planning and implementation to allow full transparency of the process. In some instances this information may be incorporated into the relevant production facility Safety Case and Verification Scheme, which normally forms the basis for all integrity management requirements and specifications.

3.4 Corrosion Risk Assessment

Planning should commence with a formal process to identify the components on a facility that have a risk of degradation due to corrosion. The most common approach to this is to conduct a Corrosion Risk Assessment [2, 9]. The purpose of the Corrosion Risk Assessment is to rank the static equipment in relation to their corrosion risks and identify options to, remove, mitigate or manage the risks. If risks cannot be removed, which is usually achieved through a change to the design, and then the corrosion threat has to either be mitigated or managed. Mitigation is achieved through the use of different materials, application of coatings, cathodic protection and chemical inhibition. Management of corrosion risks is achieved through the introduction of a corrosion monitoring and inspection programme.

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Ideally the Corrosion Risk Assessment identifies the corrosion / degradation threats to each item of process equipment, assesses the remaining life, and feeds the information back into the overall risk assessment and control system. The Corrosion Risk Assessment may also be used to assign priorities for corrosion monitoring and corrosion management procedures, including input into Risk Based Inspection (RBI) schemes.

A Corrosion Risk Assessment is a formal review that identifies the probability of a corrosion-related

failure and its consequences relating to the loss of containment and the consequential hazards should a failure occur. Corrosion Risk is normally expressed as the product of the probability of corrosion related failure and the consequences of such a failure.
The Corrosion Risk Assessment model should ideally be maintained live throughout the asset life, and requires regular review of the data employed and the assumptions used. The results of the corrosion monitoring and inspection activities should be fed back into the Corrosion Risk Assessment model to validate its assumptions, or modify them accordingly. (figure6)

3.5 Risk Based Inspection

Risk Based Inspection (RBI) schemes are a planning tool used to develop the optimum plan for the execution of inspection activities. RBI uses the findings from a formal risk analysis, such as a Corrosion Risk Assessment, to guide the direction and emphasis of the inspection planning and the physical inspection procedures.
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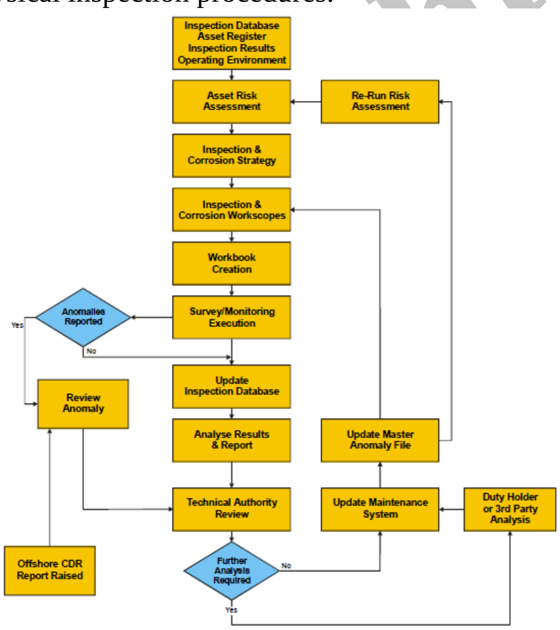

Figure 6

Example of Corrosion Monitoring & Inspection Planning and Data Analysis [2, 3]

A risk based approach to inspection planning is used to [2, 4]:
Ensure risk is reduced to as low as reasonably practicable Optimize the inspection schedule
Focus inspection effort onto the most critical areas
Identify and use the most appropriate methods of inspection Risk Based Inspection methodologies are well described in published documents such as API 581 [12] or Det Norske Veritas RP G-101[13]. Where such a Risk Based Inspection scheme is used, it should be noted that the determination of future inspection requirements, by extrapolation of historical trends, is based on an assumption that the conditions in the future are similar to those in the past and that there is no change in degradation mechanism(s).
Any significant change in operating conditions (for example water break through, increase in CO_2 content, change in wax or scaling tendency, etc), could result in significant changes in corrosion rate and/or corrosion damage, which could in turn lead to different inspection requirements [10]. It is therefore appropriate for the model which is driving the Risk Based Inspection scheme to be re-run either at specific time intervals, or when a process variable exceeds a previously agreed boundary condition.
On new assets or in the absence of good quality historic data on mature assets, it is normally considered good practice to carry out a baseline survey to establish a known condition from which to monitor. Where such a Risk Based Inspection scheme is used, it should be noted that the determination of future inspection requirements, by extrapolation of historical trends, is based on an assumption that the conditions in the future are similar to those in the past and that there is no change in degradation mechanism(s).
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3.6 Planning

The next step in the planning cycle is to schedule the corrosion management activities. Corrosion management planning should be based on the corporate, long-term strategies and objectives for the production facility. Corrosion management is not a standalone process and therefore the scheduling of activities needs to be integrated with the operations and maintenance plans for any particular facility. It is common for both long term, circa 5 years, and short term, circa 12 months, plans to be developed. Final detailed scheduling of activities is often linked to more short term 60-90 day operations plans. Planning can be divided into three main areas:

Work Planning: The main functions of the work planning stage may include scheduling and integrating the inspection and monitoring activities within the overall asset strategy, and identifying the preferred deployment of inspection and monitoring resources and technology. This includes the development of work packs for campaigns of activities.

Resource Planning: identification of both personnel and physical needs over identified time periods should be built into the implementation stage from the planning stage.

Methods and Procedures: it is generally considered appropriate that the techniques and procedures to be used and followed during the implementation phase should be clearly identified. Written procedures are required for all aspects of implementation of the corrosion management plans in order tonsure consistency in the data collection, definition of criteria on nonconformance and specification of clear lines of authority and reporting.

During the planning stage the Key Performance Indicators/performance standards for asset corrosion management system should also be identified and agreed with the asset management team.

3.7 Implementation

Management of the corrosion risks is achieved through a combination of proactive and reactive monitoring measures. Proactive measures are where the requirements and implementation of the monitoring system or inspection programme are identified and put in place before any corrosion or deterioration has been observed, based on either output of a Corrosion Risk Assessment or based on some other review/identification of areas of possible/likely corrosion.

Reactive measures are implemented after a problem has been identified (either as a consequence of proactive monitoring or because of an incident or observation of a problem).

Proactive monitoring itself comprises of in-line (figure 7) and on-line systems these involve the collection of data, which enhances knowledge of the rate of corrosion degradation and allows steps to be taken which will prevent failure and off-line systems where techniques that retrospectively identify corrosion degradation and quantify the causes/onset, extent and degree to which it has occurred are employed. Reactive monitoring will normally be limited to off-line systems, and are also normally aimed at quantifying the extent/distribution of any deterioration that has occurred.

Successful management of corrosion requires that cost-effective combinations of various mitigation procedures be employed to minimize risks to asset integrity, to control hydrocarbon releases and to ensure safety. The choice of corrosion control for any specific asset depends on factors such as fluid composition, pressures and temperatures, aqueous fluid corrosivity, facility age and technical culture of the organization.

Figure 7
In-Line Inspection Equipment
(Intelligent Pig, Rosen Company)

Corrosion inspection and monitoring are key activities in ensuring asset integrity and control of corrosion. Field data and the results of laboratory evaluations should be trended to obtain up-to-date corrosion information. Management decisions on equipment condition, prediction of remnant life and requirements for chemical treating are only as good as the information input provided from field experience. Corrosion inspection and monitoring includes assessment of:

- Operating environment, including changes in produced fluids compositions
- Metal wastage
- Pitting (including extent, depth and growth rate)
- Erosion and erosion corrosion
- Environmental cracking
- Fluid corrosivity assessments
- Development of biological activity

Whether data is collected from planned or opportunity inspections, it is of immense value when awareness of corrosion issues is increased across the workforce as a whole. This ensures that at every available opportunity, areas where corrosion could be a problem are looked at. Similarly it is important that non-specialist staff understand that corrosion damage, which will always start small, can increase at an exponential rate if not checked in time.

3.8 Data Gathering & Storage

Information from corrosion management and inspection activities should be collated and gathered together to enable data assessment. This information should also include relevant process conditions and chemical inhibition data.

3.8.1 Data Gathering

Typically the data gathered will include:
Process conditions, highlighting any changes
Visual observations
Corrosion monitoring data
Weight loss coupons,
Electrical resistance (ER) probes

3.8.2 Data Storage

During the planning and implementation stage careful consideration of data storage, data management and data analysis is required. Electronic data storage is considered beneficial by many operators for ease of data management, however, manual paper based systems are also used successfully, especially for smaller or mature assets. In either case careful consideration should be given to the upkeep of data, where and how it is stored, and who requires access to it. The latter point is particularly important where several different organizations are engaged in the corrosion management process.

3.9 Data Analysis

The individual responsibility for data collation and data analysis should be clearly identified, and the reporting structure evident [10,11]. The reporting period of corrosion data should be in keeping with the potential safety impact of the data assessed, and should be delivered on time. Once the available information has been assessed, it may be combined with the data from the Corrosion Risk Assessment to perform a risk based analysis. The analysis should assess the potential for, and the consequences of, failure of item of equipment on the asset, with safety critical items being singled out for special attention.

3.10 Reporting

Anomaly reporting, responsibilities and procedures should be in place to ensure that, when anomalies are identified, they are reported in a timely manner and recommendations for their resolution are acted upon. The reporting structure for anomalies is particularly important where alliances are in place between the asset owner and one or more contractors. Positive acknowledgement of completion of actions is required in order to assure that the loop from anomaly reporting through to resolving the anomaly is completed. Relevant information and lessons learned should be fed back into the Corrosion Risk Assessment document. This is equally applicable both in the event that corrosion is found and when corrosion is not evident where it was anticipated.

3.11 Corrective Action

Once the Corrosion Risk Assessment has been completed and/or corrosion monitoring and inspection data have been collected and analyzed the necessary corrective action(s) required need to be identified and put into place[12]. The options available will depend upon the type of facility and the nature/extent of the damage/deterioration identified.

RESULTS AND DISCUSSION

A corrosion management system has been outlined; it is compatible with the requirements of an offshore safety management system concerned with ensuring the integrity of topside processing equipment. That is, employers should have effective plans and organizations to control, monitor and review preventative and protective measures to secure the health and safety of persons.

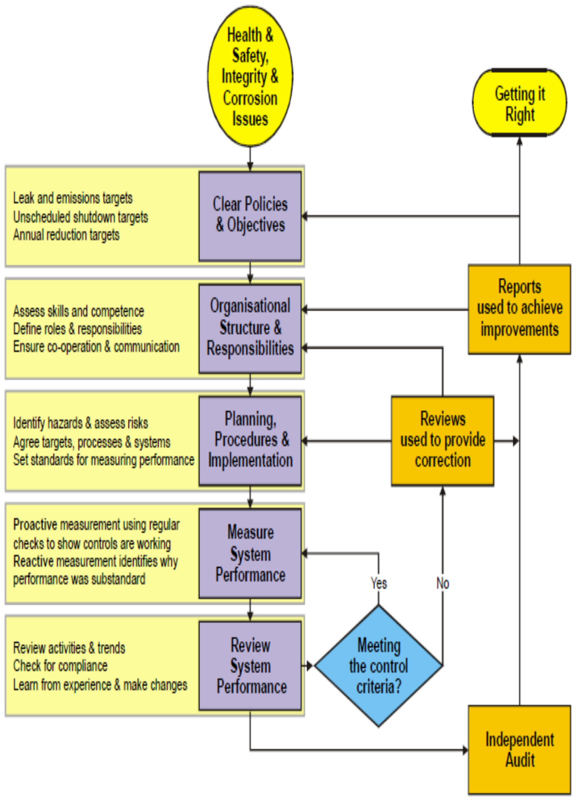

Figure 8
Basic Corrosion Management Process to Ensure Safe Operation [3]

Such a system, as shown in Figure 8 can operate at various managerial and technical levels within an organization. The degree of complexity will depend on both the size of the operation - the number of personnel, the roles and responsibilities of managers, engineers, technical support staff and contractors. The system will also have technical input in terms of risk assessments for safety critical items and control systems such as availability of chemical treatment, corrosion inspection and corrosion monitoring, which in turn is determined by the materials of construction (corrosion resistant alloy versus carbon-steel), the fluid corrosivity, water cuts, age of the production system and maintenance strategies adopted.

4. SAMAN OFFSHORE PLATRFORM GENERAL DATA

This enormous steel structure consists of 10 main platforms and 46 satellite platforms. The main interest in this pilot study is to manage the technical integrity of the New Production Platform (NPP), which is the mother processing unit of this offshore complex. A schematic of the complex is shown in Figure9.

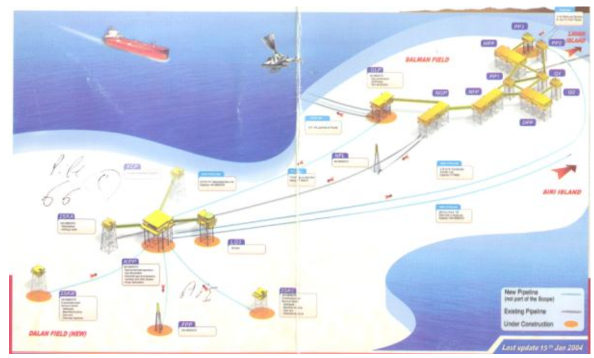

Figure 9
Salma and Dalan field overall Schematic

In summer 2010, an infrastructure technical integrity was developed based on the API 581 guidelines and was conducted by Eng.Yazdani in SALMAN offshore complex. The NPP platform was selected as the pilot study and after the emplacement of corrosion prone area, the UT procedure compiled. By using similar method that explained before following list presents the main conclusions from this study.

a)It is possible to extend the inspection time interval of 17% of the assessed the equipment without the any concern about integrity of the platform .on the other hand ,83% of the fixed equipment of NPP are subjected to high risk and need more preventive maintenance .

b)By the selecting the corrosion prone the area on the vessel’s drawing, the number of points to be inspected via a scanning UT procedure has reduced about 60%. The traditional UT spot wall thickness measurement every 5-yaers, contained an average of 25 points for every vessel. But after the average mark up of CMLs in 10 point for each vessel, the time and money will be saved.

c) The conventional spot thickness measurement shall be replaced by UT wall thickness scanning with phased array probes to be able to detect the pitting corrosion and calculate the corrosion rate in more reliable manner.

d) The poor documentation of the inspection and maintenance procedures history make it difficult to decide about some feature such as probability assessment and corrosion rate calculation. But after implementing such projects and designing required forms for any responsible personnel to fill out will solve this problem in near future.

e) Critical piping such as vessel outlet piping up to fist isolation valve where CRA vessel or carbon vessel with internal coating. CMLs are required to ensure corrosion for such piping can be detected timely to avoid loss of inventory.

f) Because of the mild corrosion characteristics of crude oil and sound corrosion protection policies, no high probability of failure is detected .but due to the importance of crude oil extraction and processing as a national production, low tolerance of down time due to management policies, the high costs of repairs and inspection activities in the offshore platform and inevitable environmental harms in a case of accident, high consequences are announced to the system.

g) By knowing reliable approximation of assets remaining life the measurement can easily coordinate the maintenance and inspection procedures needed to assure its availability of equipment and continuity of its production operation .also a logical spare part optimization is accessible.

h) There are a number of factors that may, in practice, make RBI difficult to implement. The first factor is time. A significant amount of staff time is needed to undertake the process systematically and effectively. The allocation of adequate financial resource up front into the risk assessment and inspection planning phased may be anther difficulty in some companies.

Especially if the return of reduced inspection costs cannot be guaranteed. RBI may lead to a requirement for the use of demonstrably more reliable inspection in some areas, and there may be additional costs of new procedure development, operator training and inspection qualification.

CONCLUSIONS

Public safety concerns have driven new regulations and corrosion control practices for oil and gas offshore facilities over the past few years. Data sharing improved areas of offshore corrosion maintenance. The newest developments center on risk assessment strategies and platform integrity management programs. The study is determined that major cost savings can be realized by developing an optimum approach that includes both inspection and corrosion management strategies. Government regulators have focused much attention on corrosion and other problems with these structures in recent years because of leaks that threaten public safety and the environment. So using a good corrosion can help to prevent environment contamination.

KEYWORDS
Corrosion – Offshore Facility- Corrosion Management

ACKNOWLEDGMENTS

Special thanks to Prof.Mohhamad Ali Golozar,the professor of the science and material engineering faculty of Isfahan University of Technology for his helps and also Mr. Mahdi Shabani, Civil engineering student of Isfahan University for paper review.

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