

Corrosion Management for Oil and Gas Assets

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Poor understanding of the corrosion management concept and its practical applications often deprives many oil and gas assets from having a proper asset corrosion management system (Asset CMS). This article tries to rectify the situation by offering a better understanding of an Asset CMS, its structure, stages, and applications. It discusses the integrity, cost, and time benefits that having and implementing an Asset CMS can bring about.

Any oil and gas asset susceptible to corrosion should have an asset corrosion management system (Asset CMS) with corrosion engineering (CE) and corrosion management (CM) components to protect it against such a threat. Many assets lack an up-to-date and functional Asset CMS with a CM component largely because of a lack of understanding of the CM concept and its confusion with CE.

To rectify this situation, oil and gas assets can be split into various groups based on their CM requirements. Thereafter, relevant remedial actions can be undertaken for each group to improve the integrity situation in general and the Asset CMS in particular. 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 strategy document. Such a document is regarded as one of the most important components of any Asset CMS. Once it is implemented, an Asset CMS can bring about many integrity, cost, and time benefits.

This article begins with explaining why many oil and gas assets experience corrosion-related issues post-commissioning. It then suggests how to categorize oil and gas assets and how to tackle their problems through providing a more in-depth understanding of an Asset CMS, its structure, and stages. Finally, it discusses the potential benefits of having and implementing an up-to-date Asset CMS in detail.

The Big Misunderstanding and Its Consequences

Corrosion is a major integrity threat to many oil and gas assets. To control and mitigate this threat, an Asset CMS with CE and CM components is needed. Asset integrity is ideally ensured and maintained through:¹

- Sound application of CE know-how and principles beginning at and mainly during the design phase

TABLE 1

This table categorizes oil and gas assets based on the condition of their incumbent Asset CMS

Asset Category	Most Prevalent or Common Symptoms
1	<ul style="list-style-type: none"> Lack of piping and pressure systems' integrity review datasheets Lack of an asset corrosion management strategy document Lack of long-term inspection planning, and inspection carried out is ad hoc and not risk-based inspection (RBI) Lack of any corrosion control matrices document Lack of inspection data processing and trending Lack of chemical treatment monitoring and evaluation Lack of regular reporting of corrosion issues and no use of corrosion key performance indicators (KPIs) Lack of various registers such as deadleg, corrosion under insulation (CUI), anomaly, leaks, etc. Lack of process flow diagrams Lack of an electronic piping specification spreadsheet Lack of any audit reports on the Asset CMS
2	<ul style="list-style-type: none"> Lack of long-term inspection planning, and inspection carried out is ad hoc and not RBI Lack of inspection data processing and trending Lack of chemical treatment monitoring and evaluation Lack of regular reporting of corrosion issues and no use of corrosion KPIs Lack of various registers such as deadleg, CUI, anomaly, leaks, etc. Lack of any audit reports on the Asset CMS
3	<ul style="list-style-type: none"> Lack of inspection data processing and trending Lack of chemical treatment monitoring and evaluation Lack of regular reporting of corrosion issues and no use of corrosion KPIs Lack of any audit reports on the Asset CMS
4	Virtually none

- Proper implementation of CM principles post-commissioning and during the operations phase

The interactions between the two throughout the asset life cycle and their blurred boundary often cause confusion for the body or corrosion engineer responsible for the asset integrity management. In spite of fundamental differences between CE and CM concepts, their principles, and applications, such confusion often leads to the common misunderstanding that CE and CM are the same thing or at least very similar.

The unfortunate misunderstanding about these CMS components illustrates itself routinely through the following:

- During the asset's operations phase, relevant CM principles, systems, and procedures are inadvertently nonexistent, neglected, and not implemented at all.
- The responsible corrosion engineer is also spontaneously assumed to be well conversant in CM or, in other words, a competent corrosion manager.

- Many operators are reluctant toward adopting an appropriate Asset CMS post-commissioning. They incorrectly believe the initial CE input at the design phase has eliminated the requirement to have an Asset CMS (with a CM component) in place.

The implications of such misunderstandings are dire and often manifested through:

- 1) Increasing risk of failure due to corrosion, leading to lower personnel safety and impaired environmental protection
- 2) Higher chemical treatment, repair, and inspection costs
- 3) An increase in the number and duration of unplanned shutdowns (either partial or total)

Categorizing Oil and Gas Assets

As explained above, there could be many oil and gas assets that suffer from various corrosion (or integrity) issues due to poor or total lack of a CM component.

An improvement plan will then be required to tackle such issues and improve the asset corrosion (or integrity) management in general. But oil and gas assets are diverse and their CM needs could vary considerably. Therefore, it is reasonable to introduce and use an asset categorization system based on which such assets can be broadly split into several groups with similar requirements or solutions.

It is suggested to use the Asset CMS as a basis for this categorization system as follows:

Category 1

Category 1 assets lack an up-to-date Asset CMS.

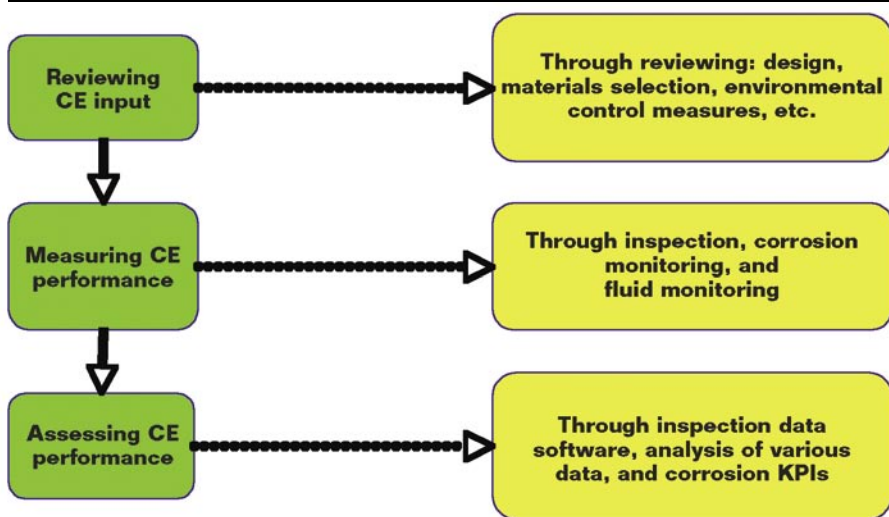
Category 2

Category 2 assets have a CMS but it is not implemented.

Category 3

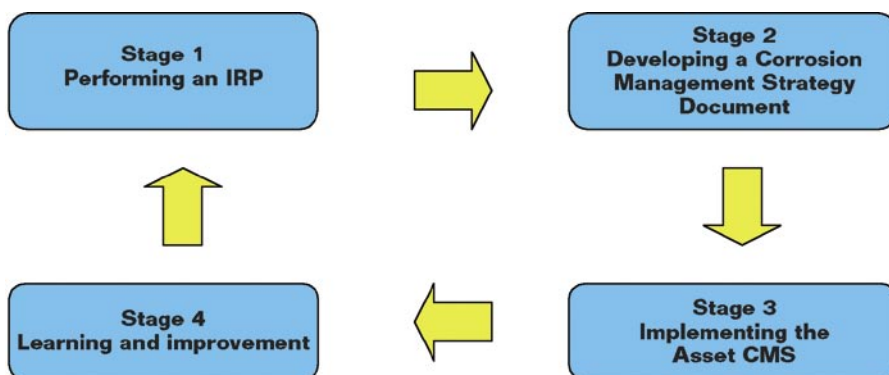
Category 3 assets have a CMS, which is being implemented, but their performance and efficiency are not regularly monitored and assessed.

FIGURE 1



The scope of the CM process.

FIGURE 2



The Asset CMS components or stages.

Category 4

Category 4 assets have a CMS, which is being implemented, and their performance and efficiency are regularly assessed.

It is of paramount importance to ascertain to which of the above categories an asset belongs. Unless an asset belongs to Category 4, it will experience corrosion issues with increasing number and intensity throughout the asset's operations phase. To aid the responsible corrosion engineer or body in determining their asset category, Table 1 lists the most common symptoms believed to be associated with each category. Please note that

this is not a comprehensive list and should not be treated as a definitive one, but only as an indicative guide. There are also some overlaps between Categories 1, 2, and 3.

Asset CMS Structure and Its Stages

Any oil and gas asset susceptible to corrosion requires proper CM. CM for any asset may be defined as the process of reviewing the applied CE considerations, the regular monitoring of their performance, and the assessment of their effectiveness post-commissioning. Figure 1 illustrates the scope of CM, which con-

sists of three stages (the green boxes) for any particular hydrocarbon asset and the tools used (the yellow boxes) to carry out each stage within that scope.

CM for oil and gas assets is achieved through an Asset CMS. An Asset CMS is a suite of procedures, strategies, and systems designed and intended to maintain asset integrity through preventing or mitigating corrosion throughout the operations phase of the asset life cycle. CM and CMS terms are often used interchangeably and synonymously by many, but they are two different concepts.

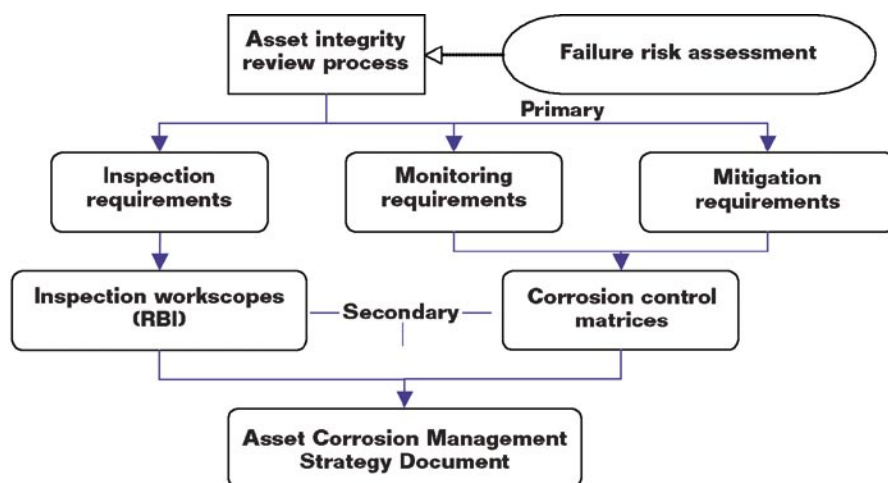
Any Asset CMS comprises four stages (Figure 2). The first stage of any Asset CMS is the integrity review process (IRP). During this stage, the responsible corrosion engineer collates the relevant design, process, operation, chemical treatment, and inspection data. Such data will enable him to carry out a system-by-system failure risk assessment at a later stage and prior to creating the corrosion management strategy document for the asset.

IRP is deemed to be the most crucial component of any Asset CMS because of its usefulness and applications, and also because of its various products. Yet, many oil and gas assets fail to conduct it. The primary products or outcomes of an IRP are:

- Determination of the inspection requirements (fully risk-based)
- Determination of the mitigation requirements
- Determination of the monitoring requirements

The complete or partial lack of appreciation of any of these requirements will lead to recurring corrosion problems with increasing number and intensity. The last two IRP products are often incorporated to produce the corrosion control matrices (CCM) document as a secondary product of the IRP (Figure 3). A CCM document is a collection of various activities designed to maintain an

FIGURE 3



The primary and secondary products of an IRP.

asset's integrity through better corrosion management. It is an indispensable ingredient of any Asset CMS.

Finally, an asset corrosion management strategy document should be produced by incorporating the relevant information (design, process, etc., collated during the IRP), process flow diagrams (PFDs), the long-term inspection plans, and the CCM document. This document will then serve as the main reference document for the corrosion engineer or the body responsible for managing asset integrity. It will include all the relevant and necessary information, diagrams, tables, and plans to tackle integrity-related issues due to corrosion.

In spite of its importance and criticality, experience has shown that there are many oil and gas assets lacking such a useful and crucial document.

From Category 1 to Category 4

Once an asset corrosion management strategy document has been produced, it has to be implemented and its implementation has to be monitored on a regular basis (Figure 2, Stages 3 and 4). These latter stages are discussed in detail elsewhere.²

Experience has shown that many oil and gas assets, in particular the more mature ones that might have also changed ownership, suffer from the lack of an up-to-date Asset CMS. Consequently, there is nothing to be implemented; hence the asset suffers from various corrosion-related issues with increasing number and intensity.

Therefore, it is of paramount importance to conduct an IRP initially, and subsequently produce an asset corrosion management strategy document. Without any such document, there are no systems, procedures, instructions, and guidelines in place to effectively manage corrosion.

Consequently, to achieve Category 4, the responsible corrosion engineer has to

focus on CMS stages (Figure 2) and determine (based on Table 1) what category his asset belongs to. Once this has been determined, then he can carry out the activities listed in Table 2, which are designed to improve the Asset CMS and achieve Category 4 upon their completions. Activities listed in Table 2 are simply an indication of the type of measures that have to be performed to improve asset integrity management. As such, they should be treated as guidelines only and not as a definitive solution or approach to an existing problem within a certain asset category.

Benefits of Having and Implementing an Asset CMS

The following have been observed for assets with an up-to-date and implemented Asset CMS:

Risk-Based Inspection

The identified inspection requirements are all risk-based when an IRP is carried out. Those assets that lack an IRP don't possess a risk-based inspection (RBI) scope. As such, inspectors often miss critical areas that could ultimately develop into leaks or failures in spite of conducting inspections.

Reduced Inspection Costs

When an IRP is carried out, the determined inspection scopes are risk-based and cover all existing and potential critical areas (i.e., areas with high corrosion rates and low remaining lives). Whereas, in the absence of an IRP, the generated inspection scopes are often more extensive to locate the critical areas. As a result, more features need to be inspected, which translates into higher costs and longer inspection times.

Reduced Repair Costs and Plant Downtime

A conservative approach is often adopted to make repairs or replacements in an area whose integrity condition is suspected or not clearly known because of inadequate inspection or lack of reliable inspection data. Such a costly approach can be avoided by generating reliable inspection data through RBI and following an IRP to better determine the fitness level or the integrity situation of an area. The latter approach prevents the need to shut down the asset to carry out unnecessary repairs or replacements.

Pre-empting Corrosion Failures

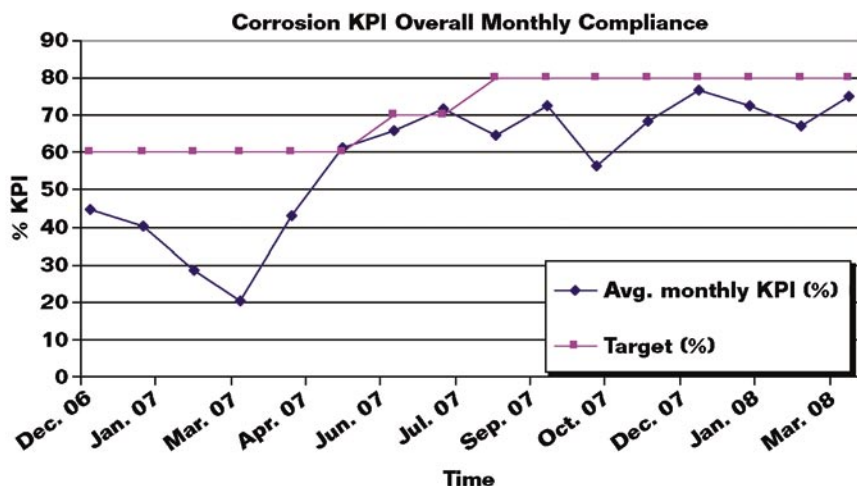
With an RBI system, all critical locations—in terms of high corrosion rates and low remaining lives—are inspected

TABLE 2

Recommended activities to improve asset integrity and eventually achieve Category 4

Asset Category	Activities to be Carried Out to Achieve or Maintain Category 4
1	Carry out an IRP for both the piping and the pressure vessels. Create or update the relevant system PFDs. Create or update line and pressure vessel lists. Determine mitigation, monitoring, and inspection requirements. Create the relevant asset strategies (e.g., deadleg, CUI, anomaly, etc.). Produce a long-term (e.g., seven years) inspection plan, which is risk-based. Produce a CCM document. Process and trend the inspection data received to locate the problem areas. Monitor chemical treatment to assess its performance and efficiency. Report on corrosion issues on a monthly basis using a corrosion KPI system. Create registers for both hydrocarbon and non-hydrocarbon leaks. Create an electronic piping specification spreadsheet. Demand an audit of the created Asset CMS.
2	Produce a CCM document. Process and trend the inspection data received to locate the problem areas. Monitor chemical treatment to assess its performance and efficiency. Report on corrosion issues on a monthly basis using a corrosion KPI system. Create registers for both hydrocarbon and non-hydrocarbon leaks. Demand an audit of the created Asset CMS.
3	Process and trend the inspection data received to locate the problem areas. Monitor chemical treatment to assess its performance and efficiency. Report on corrosion issues on a monthly basis using a corrosion KPI system. Demand an audit of the created Asset CMS.
4	Carry out an IRP when required to update relevant data, strategies, and documents.

FIGURE 4



Continuous improvement in the performance of an Asset CMS post implementation.

as regularly as required. Therefore, the generated inspection data will aid the responsible corrosion engineer to continuously estimate corrosion rates and remaining lives for such areas and plan remedial actions before an area develops a leak from corrosion.

Optimizing Chemical Treatment

In the absence of a thorough IRP, many chemicals are either underdosed or overdosed. The former will promote higher deterioration rates while the latter is not economical. Monitoring the performance of an Asset CMS will aid

the responsible corrosion engineer in appraising the performance of the chemical and optimizing the dosing of chemicals.

Improving Teamwork and Performance

Reporting Asset CMS performance on a regular basis using a corrosion key performance indicator (KPI)² system often generates and increases motivation among team members. This progressively improves teamwork and cooperation within the team and leads to higher corrosion KPIs and enhanced corrosion management. Figure 4 illustrates such an outcome for a gas refinery in South Asia. Team performance was reported using a corrosion KPI system on a monthly basis. The original overall KPI target level was 60% (at the beginning of 2007 when implementation of the new Asset CMS began) and it was raised twice because of constant improvements in the implementation and performance of the Asset CMS from the improved teamwork.

Conclusions and Recommendations

The existing confusion about the CM concept and its blurred boundary with CE has had dire implications for many oil and gas assets. To tackle this problem, it is recommended to split such assets into different groups based on the condition of their Asset CMS and its implementation. Performing an IRP is considered the best and most common solution to rectify many corrosion-related issues. The main IRP outcomes are then used to generate or update the Asset CMS. Consequently, implementing the generated Asset CMS will bring about many integrity, cost, and time benefits. This solution is even more applicable to those assets that have already passed their design life or have been managed and owned by more than one operator post-commissioning.

References

- 1 A. Morshed, "Offshore Assets: From Corrosion Engineering to Corrosion Management," *MP* 46, 10 (2007): p. 34.
- 2 A. Morshed, "Improving Asset Corrosion Management Using KPIs," *MP* 47, 5 (2008): p. 50.

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