Improving Asset Corrosion Management Using KPIs

Ali Morshed, *Production Services Network (PSN), Aberdeen, U.K.*

To mitigate the threat of corrosion in any oil and gas asset, an asset corrosion management strategy (CMS) is required. Once the asset CMS is implemented, its performance should be monitored and assessed on a regular basis to maintain and improve asset integrity. Corrosion key performance indicators (KPIs) are powerful tools and can be used for this purpose. This article provides a detailed account on how corrosion KPIs are selected and expressed, as well as the benefits of their use.

Proper corrosion management for any oil and gas asset should be achieved through an asset corrosion management strategy (CMS). Implementing the asset CMS will ensure that all the possible corrosion-related threats identified earlier are managed and mitigated so the integrity of the asset is maintained. To ensure that the created asset CMS is relevant, efficient, and up-to-date at all times, its performance should be monitored and assessed on a regular basis.

Corrosion key performance indicators (KPIs) are valuable tools for monitoring CMS performance. They are selected from the activities listed in a typical corrosion control matrices (CCM) document and then reported on a monthly basis in the form of percentage compliances. They not only render corrosion reporting easy, straightforward, and quick, but also significantly help maintain and improve the integrity of the process pressure systems in any hydrocarbon asset.

Ultimately, using corrosion KPIs as part of any asset CMS will lead to the following benefits:

- Improved personnel safety and environmental protection
- Reduced plant downtime
- Reduced cost of maintenance, inspection, and chemical treatment

This article provides a comprehensive understanding of corrosion KPIs, including how they are selected, expressed, and used, and the benefits of their use.

Corrosion and Corrosion Management Strategy

Corrosion is regarded as a primary threat to the integrity of any oil and gas asset, such as refineries, offshore platforms, and pipelines. Therefore, corrosion management is required to mitigate and control corrosion. For any asset, proper and efficient corrosion management is always achieved through an asset

CMS. A CMS is defined as "a suite of procedures, strategies, and systems to maintain asset integrity through preventing or mitigating corrosion throughout the asset's operation phase."[1]

Any CMS comprises four components or stages in the form of a loop, as depicted in Figure 1. The process of creating an asset CMS begins with conducting an integrity review process (IRP). During the IRP, the responsible corrosion engineer collates various data and information to perform failure risk assessment and to determine the corrosion risk on a system-by-system basis for the whole asset.

Once the asset CMS has been developed and finalized or updated (as is the case in later years), it has to be implemented. With regard to an asset CMS and its implementation, oil and gas assets can be divided into the following four categories:

1) Assets that lack an up-to-date asset CMS
2) Assets that have a CMS, but it is not implemented
3) Assets that have a CMS being implemented, but whose performance and efficiency are not regularly monitored and assessed (i.e. missing stage 3 in Figure 1)
4) Assets that have a CMS being implemented and whose performance and efficiency are assessed regularly

Unless an asset belongs to category 4, it will suffer from corrosion issues with increasing number and intensity throughout the asset's operations phase. Such assets are manifested by:

- Decreasing personnel safety and environmental protection
- Increasing number of planned and unplanned shutdowns
- Increasing cost of maintenance, repair, inspection, and chemical treatment

FIGURE 1

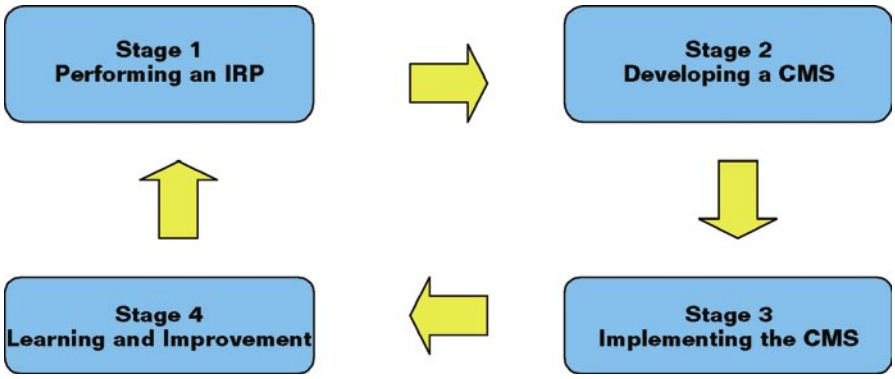


Illustration of the CMS components or stages.

Regular monitoring of the performance and efficiency of any asset CMS being implemented is carried out through corrosion KPIs. This corresponds to the fourth stage of any CMS structure (Figure 1), which is "Learning and Improvement."

This article mainly targets assets within category 3 and explains how the asset CM can be improved by using corrosion KPIs, and through regular assessment of the performance of the asset CMS. The first step in doing so is to determine a set of corrosion control matrices for the asset.

Corrosion Control Matrices

A CCM document is a collection of various activities designed to maintain an asset's integrity through better corrosion management. A CCM document is an indispensable component of any asset CMS and a secondary product of the IRP. The primary products or outcomes of an IRP are:

- Determination of the inspection requirements
- Determination of the mitigation requirements
- Determination of the monitoring requirements

The last two components are often incorporated to produce the CCM document as a secondary product of the IRP. The CCM document comprises various tables or matrices associated with the relevant asset systems or operations. Each table or matrix then contains a list of activities relevant to the process or features of the corresponding system or operation. Most of these activities are intended to identify the possible key physical and chemical changes in any of the asset's operating processes and key fluid elements that have significant impact on corrosion.

Each table or matrix aims to provide improved corrosion control by listing the crucial monitoring and control activities with a designated person assigned to each activity. The regular implementation of each activity as detailed in each matrix will contribute to the integrity of the corresponding system or operation.

The monitoring and control activities, where appropriate, have associated threshold values that, if exceeded, will prompt additional activities to remedy or mitigate the threat of increased corrosion. Matrices are normally split into the following fields for further clarification and to facilitate the implementation of each activity:

- Responsible person
- Definition of activity
- Location
- Frequency
- Threshold

Table 1 is an illustration of a typical matrix belonging to a gas processing facility that receives offshore wet gas through a gas transfer pipeline.

TABLE 1

An example of a typical set of activities pertaining to a gas-processing facility and its gas transfer pipeline

Ref. No.	Responsible Person	Activity	Location	Frequency	Threshold	Corrective Actions
1.1	Offshore chemist	Monitor corrosion inhibitor injection rate	Upstream of export manifold on platform	Daily	200 ppm (in water phase)	Optimize injection rate. Notify maintenance supervisor
1.2	Onshore chemist	Monitor pipeline water cut	Slug catcher	Daily	None	Adjust dosage rate to threshold level. Notify maintenance supervisor
1.3	Onshore chemist	Monitor pipeline fluid pH	Slug catcher	Daily	None	Notify maintenance supervisor
1.4	Onshore chemist	Monitor pipeline fluid residual corrosion inhibitor	Slug catcher	Daily	220 ppm (in total fluids)	Notify maintenance supervisor
1.5	Onshore chemist	Monitor iron count in the pipeline fluid	Slug catcher	Daily	None	Notify maintenance supervisor
1.6	Onshore chemist	Bacterial monitoring	Slug catcher	Monthly	Presence of sulfate-reducing bacteria/ general heterotrophic bacteria activity	Notify corrosion engineer
1.7	Production supervisor	Pipeline pigging	Pig launcher	Annually	None	Notify maintenance supervisor
1.8	Onshore chemist	Monitor water content of lean glycol	Glycol skid	Daily	<0.5 vol% water	Confirm correct operating conditions of glycol skid. If necessary, drain and refill. Notify maintenance supervisor
1.9	Chemist	Monitor pH of lean glycol	Glycol skid	Daily	6.0 < pH < 9.0	Add pH buffer to glycol skid (tank). Notify maintenance supervisor
1.10	Maintenance	Ultrasonic testing inspection of pipeline elements	Platform	Inspect within 1/2 remaining life	Corrosion rate > 0.125 mm/y	Notify maintenance supervisor

Note: Underlined items denote activities that were selected as corrosion KPIs.

TABLE 2

A typical KPI table within an asset corrosion monthly report

Performance Measure	System	Target Value/Range	% Compliance
Corrosion inhibitor concentration	Pipeline	200 ppm (in water phase)	93.5
Lean glycol water content	Glycol regeneration	<0.5%	12.9
Lean glycol pH	Glycol regeneration	6.0 < pH < 9.0	100.0
Corrosion inhibitor residual concentration	Pipeline	220 ppm (in liquid phase)	100.0
Average compliance			76.6
The compliance target level			80.0

Corrosion KPIs and Their Selection

Corrosion KPIs are key CCM activities that can be used as indices or indicators to monitor the performance and efficiency of the asset CMS. Regular monitoring of their performance will immediately reveal whether an asset CMS has been functioning satisfactorily or not.

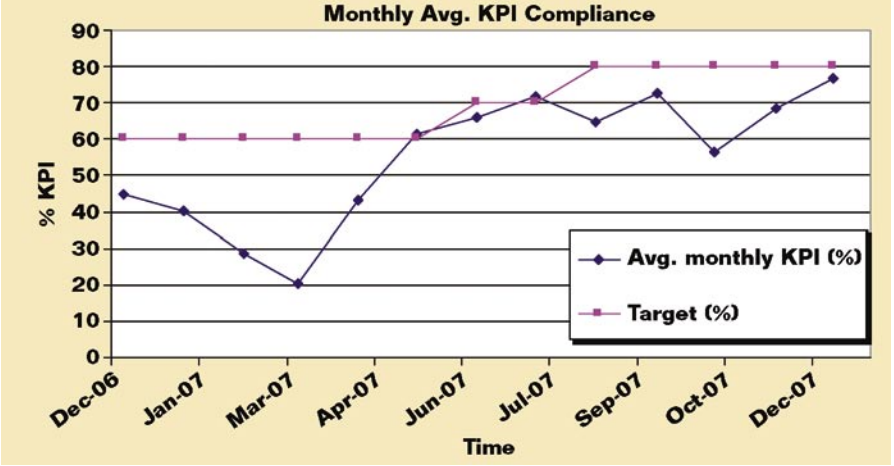
KPIs are also regarded as an indispensable tool in maintaining and improving asset corrosion management.

Normally any CCM document comprises many different activities whose regular implementation contributes to the overall asset integrity or to the asset corrosion management. However, some of these activities play a more significant role in mitigating corrosion and maintaining the integrity of the asset. The performance of such activities can, in general, better reflect the successes and/or the shortcomings of the asset corrosion management system.

The relevant corrosion KPIs should always be selected from the activities listed in a CCM document. Selecting the most appropriate CCM activities as corrosion KPIs is a delicate job and it requires the discretion of a responsible corrosion engineer.

For example, in Table 1, of the 10 listed CCM activities for a gas processing asset receiving wet gas through a pipeline, only the underlined activities have been selected as corrosion KPIs because of their perceived crucial contribution to maintaining the integrity of the gas processing facilities and the gas transfer pipeline.

FIGURE 2



Plotted average monthly compliance against the compliance target level.

Calculating, Managing, and Reporting Corrosion KPIs

Once the appropriate CCM activities have been selected as corrosion KPIs, they will normally be calculated on a daily basis and expressed and reported as percentage compliance on a monthly basis; preferably within the asset monthly corrosion report.

To be able to express corrosion KPIs as percentage compliance, each CCM activity selected as a corrosion KPI should preferably have either a defined range or a threshold value (e.g., activities 1.1 and 1.4 in Table 1). As long as the measured/calculated value is within the defined range or has not exceeded the threshold value throughout any particular day, it is considered to be compliant for that day. For a 30-day month, each day is equal to 3.3% compliance. Therefore, at the end of each month, the number of compliant days should be added and then multiplied by 3.3% to determine the monthly percentage compliance for that particular KPI. Once all monthly compliances are determined for all the selected KPIs, the average percentage compliance for that month should be determined.

Normally, a compliance target level is also defined and used as a benchmark to evaluate the overall performance of the calculated monthly average compliance. The value of the compliance target level depends on the following parameters:

- Client expectations
- Recent performance of the monthly average compliance
- The responsible corrosion engineer's judgment

A spreadsheet can be used to perform all the necessary calculations to determine individual KPI levels, their monthly average, and to plot the required graphs.

Table 2 is an illustration of a typical KPI table in an asset monthly corrosion report where each individual activity along with its corresponding range or threshold, monthly performance, and compliance target level are listed.

Figure 2 is a plot of the average monthly compliance vs. the agreed compliance target level over a 13-month period (taken from a real case). Note that the target level was raised twice as the average monthly compliance continued to improve.

Using Corrosion KPIs and Their Benefits

Once a corrosion management system has been developed and implemented, its implementation has to be regularly monitored and assessed to:

- Evaluate the performance and efficiency of the asset CMS
- Ascertain that the asset CMS remains relevant, functional, and up-to-date at all times
- Identify any shortcomings or gaps in the implementation of the asset CMS
- Continuously improve asset corrosion management through steady improvement of the individual and average KPI compliances

Once the asset CMS has been implemented, using corrosion KPIs has several primary and secondary (direct and indirect) benefits. The primary or direct benefits are:

1) Corrosion KPIs are an efficient way of capturing, trending, and assessing data related to the most important activities affecting the integrity of the process pressure systems of an asset.
2) They can help to immediately identify shortcomings or problems during the implementation phase of the asset CMS. This is of great benefit; in particular, to the mature assets suffering from various acute corrosion problems.
3) They improve the supervision of the responsible corrosion engineer over the most crucial activities (related to the asset integrity) and the individuals who have to regularly carry them out.
4) They help improve motivation among the team as team members constantly endeavor to achieve higher individual and average KPI compliances.
5) Corrosion KPIs are an efficient, quick, and brief way of reporting issues related to asset integrity and asset corrosion management; in particular, to the senior management.

Since using corrosion KPIs maintains and improves the integrity of the process pressure systems of an asset, the following can be considered as the secondary or indirect benefits of using corrosion KPIs:

1) Improving personnel safety and environmental protection
2) Reducing plant downtime through reducing the number of unplanned shutdowns
3) Reducing the cost of maintenance, inspection, and chemical treatment

Conclusions and Recommendations

Once an asset CMS has been implemented, its performance and efficiency should be monitored and assessed regularly and reported preferably on a monthly basis. Corrosion KPIs are regarded as the very tool required to do this job. They are:

- Selected from the activities listed in the CCM document
- Normally calculated on a daily basis
- Expressed as percentage compliance in regard to some defined ranges or threshold values

It is highly recommended to corrosion engineers responsible for the corrosion (or integrity) management of assets to use corrosion KPIs due to the following main benefits:

- Corrosion KPIs are an efficient way of assessing data related to the asset corrosion management.
- They can immediately identify shortcomings during the asset CMS implementation phase.
- They improve the supervision over the most crucial activities (related to the asset integrity) and the individuals who have to regularly carry them out.
- They improve motivation and promote teamwork among the team members.
- Corrosion KPIs are a quick and brief way of reporting to the senior management.

Reference

1 A. Morshed, "Offshore Assets: From Corrosion Engineering to Corrosion Management," *MP* 46, 10 (2007): p. 34.

ALI MORSHED is the principal corrosion engineer at Production Services Network (PSN), Wellheads Place, Dyce, Aberdeen, AB21 7GB, U.K. He has years of experience in asset integrity management in the hydrocarbon industry, specializing in producing and implementing asset corrosion management strategies. He received a Ph.D. grant from BP to do research on sweet corrosion of carbon steel oil transfer pipelines (1997 to 2001), has an M.S. degree in corrosion of engineering materials from Imperial College (London, 1997), and has authored several publications. *MP*