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Corrosion Control of Risers

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Abstract

Risers are located in environmentally sensitive areas and are exposed to corrosion risks. Risers are more prone to internal corrosion than external corrosion. The overall risk for this infrastructure is high. Further, given its location, the consequence of failure is also high. Risers typically have a lifetime of greater than 10 years. Effective management of the corrosion risks in raisers is required so that their contribution to overall risk is low. Corrosion control of risers can be assessed using Key Performance Indicators (KPIs). KPIs ranging from 0-1 are considered good; 2-3 are considered fair, while 4 and above are considered poor. In this paper, application of 50 KPIs for tracking effective implementation of corrosion control strategies is evaluated.

Introduction

Risers are important constituents of the off-shore oil and gas industry. These are conduits that facilitate transfer of materials from the seafloor to production and drilling facilities above the sea level and vice-versa. They typically transport produced hydrocarbons, production materials, and injection fluids. Riser Integrity Management (RIM) is executed in order to assure safe and cost effective operation of the risers for their entire lifecycle. It is important to emphasize the criticality of this unit with respect to personnel, assets, operation and environment[1]. The scope of work for the riser is typically between the seabed limit (last flange off the manifold, pipeline end termination, mud line) to the topside limit of pig trap or main block valve as shown in Figure 1.

Corrosion is one of the major risks faced by risers. Risers are exposed on the internal side to crude, produced water, sands and corrosive gases such as CO_2 and H_2S. So, several mechanisms of internal corrosion can be operational. It should be noted that NACE MR0175 excludes material used in drilling riser systems from qualification for H_2S corrosion[2].

Context of Corrosion Control

Risers are located in environmentally sensitive areas. The overall risk for risers is high given their location and nature of operation. They typically have a lifetime of greater than 10 years. Risers are more prone to internal corrosion than external corrosion. Therefore an effective management of the corrosion risks is required for safe and cost effective operation of risers. Corrosion control of the risers can be assessed using Key Performance Indicators (KPIs) as summarized in Table 1 and Figure 2. KPIs ranging from 0-1 are considered good; 2-3 are considered fair, while 4 and above are considered poor[3].

Internal Corrosion

Model: The material used for constructing risers is typically carbon steel, with stainless steel and titanium being used to some extent. Flexible risers are also used in the industry. The risers are exposed to aggressive internal environments. These can affect fatigue and fracture performance and reduce predicted service life. There could be conditions in downstream and upstream of the sector that could have an impact on the corrosion risk for the risers. The following could be the possible causes:

- Corrosion inhibition shut down
- Decrease in temperature that could lead to hydrate formation.
- Increase in produced water that could lead to a different water cut.
- Change in the nature of emulsion, i.e., change from water in oil emulsion to oil in water emulsion, can potentially lead to an increase in corrosion risk

The above mentioned risks could have an impact on general corrosion rate in case of corrosion inhibition failure. Formation of hydrates can plug the risers and can prevent corrosion inhibitor from reaching the pipe internal surface. Change in water cut can lead to change in partitioning behavior of inhibitor and hence change in general corrosion rate. Change in nature of emulsion can have an impact on change in the percentage of internal surface of riser exposed to water. These are some of the risks that should be assessed with respect to corrosion. It should be assured that internal corrosion rate after maintenance activities remain below the value that was prior to the maintenance activity. The opportunity of maintenance activity should be exploited to ensure that the remaining wall thickness is within acceptable limits.

Mitigation: Mitigation strategy is based on the risk categorization and should be part of the preventive maintenance program for the risers. It should be initiated in the design phase itself with considerations to corrosion inhibition, internal linings etc. The mitigation strategy should include steps to control the initiation and propagation of internal corrosion. The key considerations should include

- Fluid type
- Determination of active corrosive components – H_2S, CO_2, water
- Flow regime
- Inhibitor type and efficiency
- Corrosion fatigue due to the cyclic loading and unloading due to sea waves
- Sulfide stress cracking susceptibility can lead to fracture toughness reduction.

The mitigated corrosion rate should be lower than the target corrosion rate, because often the corrosion allowance is kept to a minimum to save costs. The target mitigation corrosion rate can be established based on laboratory testing using either standard or non-standard methodologies or field experiences. Efficiency of corrosion inhibitors in environments of interest is often tested using laboratories methodologies such as rotating cylinder electrode and flow loop.

Susceptibility of riser materials to sulfide stress cracking is often ascertained using laboratory testing methods described in NACE TM0175[4]. Methods based on fracture mechanics are used to determine stress intensity factor of stress corrosion cracking (K_{1SSC}) and susceptibility of materials to corrosion fatigue issues.

Monitoring: Monitoring is an important step of the corrosion management strategy in order to ensure that the actual corrosion rates under given conditions are less than or equal to target corrosion rate. Monitoring as part of RIM can be periodic inspection or continuous monitoring. Variation in the process fluid can lead to accelerated corrosion. Corrosion rate can be ascertained using techniques such as smart pig and corrosion coupons. Pigging products, residual inhibitor analysis, and fluid analysis can also be used to monitor the fluid characteristic and its impact on corrosion rate. An effective monitoring strategy would be to monitor corrosion rates using different techniques and to ensure that there is agreement between the different techniques used. The monitoring techniques should be validated to ascertain that the data obtained is representative. Corrosion rate calculated from actual remaining thickness during maintenance activity can be used to validate different techniques.

External Corrosion

The risers normally do not undergo extensive external corrosion. External corrosion of the riser pipe materials may be general and pitting corrosion. The external surface can be inspected using ultrasonic probe.

Measurement

Measurement data to assess corrosion conditions are mostly available. However, there are challenges associated with obtaining data in readily usable format as they are usually collected for reasons other than corrosion control. The measured data should be properly integrated to obtain corrosion rates and the corrosion rates obtained should be validated against baselines obtained from laboratory measurements.

Maintenance

Risers are designed to operate under optimum conditions. However, there are occasional fluctuations from the normal operating conditions and these fluctuations such as internal pressure fluctuations could potentially lead to leaks. Temperature and pressure conditions may change during the life of the risers. Risers are also operated beyond their design life. The corrosion issues needs to be properly accounted for by either conducting laboratory experiments in the new environment or collecting field data to assure that the corrosion rate is below the desired rate. A confidence level need to be developed based on the above to ensure safe operation of the infrastructure.

The maintenance can be preventive or corrective depending on the degree to which the risk has been allowed to escalate. The aim of the maintenance should be to optimize maintenance cost and minimize lost production time. More importantly the maintenance activity should improve the integrity and safety of the raisers. The maintenance activity should be carried out according to a maintenance plan, using a competent workforce capable of delivering a quality work. The data obtained from the maintenance activity should be properly recorded in appropriate databases in form that are readily usable form. DNV-RP-F206 provides general guidelines for carrying out maintenance activities.

Management

There needs to be an effective communication plan for proper management of riser. Plans need to be developed for both internal and external communication. Internal communication could be in the form of regularly scheduled meetings. The sector does seem to have an effective internal communication strategy; however, there is a perception that the internal communication tends to be on an ad-hoc basis. External communication needs to be accurate, objective and transparent. The external communication could be to failure investigators, regulators, stakeholders or public. Deficiencies in this aspect of communication were somewhat apparent in some of the case histories that were studied in the course of writing this paper.

The RIM system in general should strive towards attaining continuous improvement by focusing on the various points discussed, in order to facilitate the O&G industry to achieve zero incidents/failures.

Conclusions

Risers in the oil and gas industry are located in highly environmentally sensitive areas and are exposed to high corrosion risks. An assessment of corrosion related risks and ways to mitigate them have been made in this paper. Evaluation of one case history indicated that improvement in internal corrosion monitoring technique and improvement in external communication strategies are needed.

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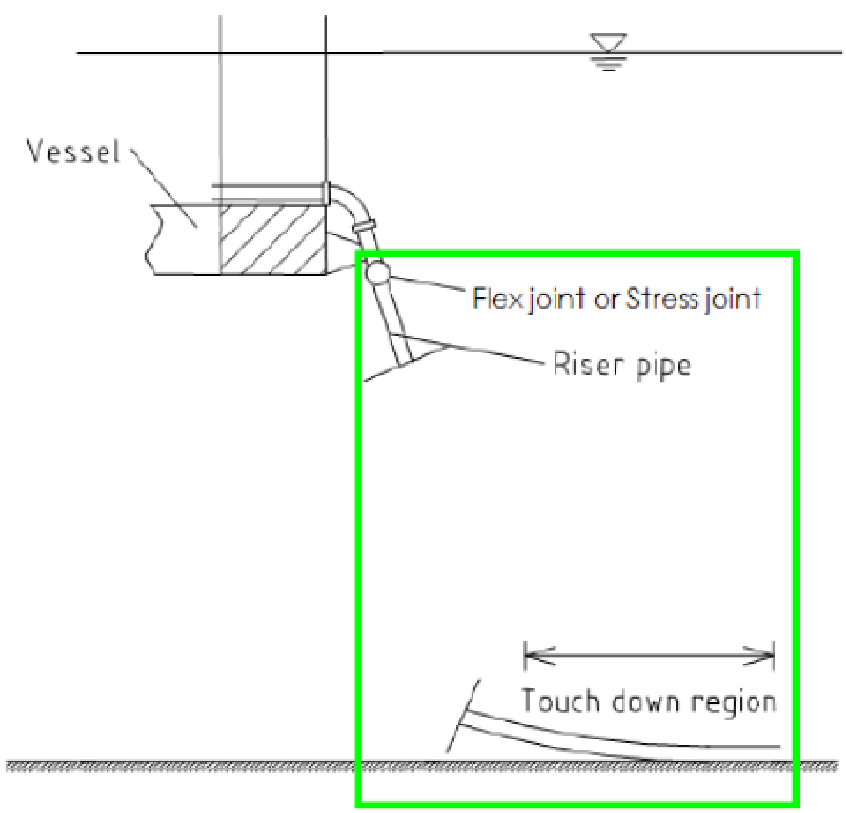

Fig.1: Scope of the Riser Integrity Management in the Oil and Gas Production Industry[1]

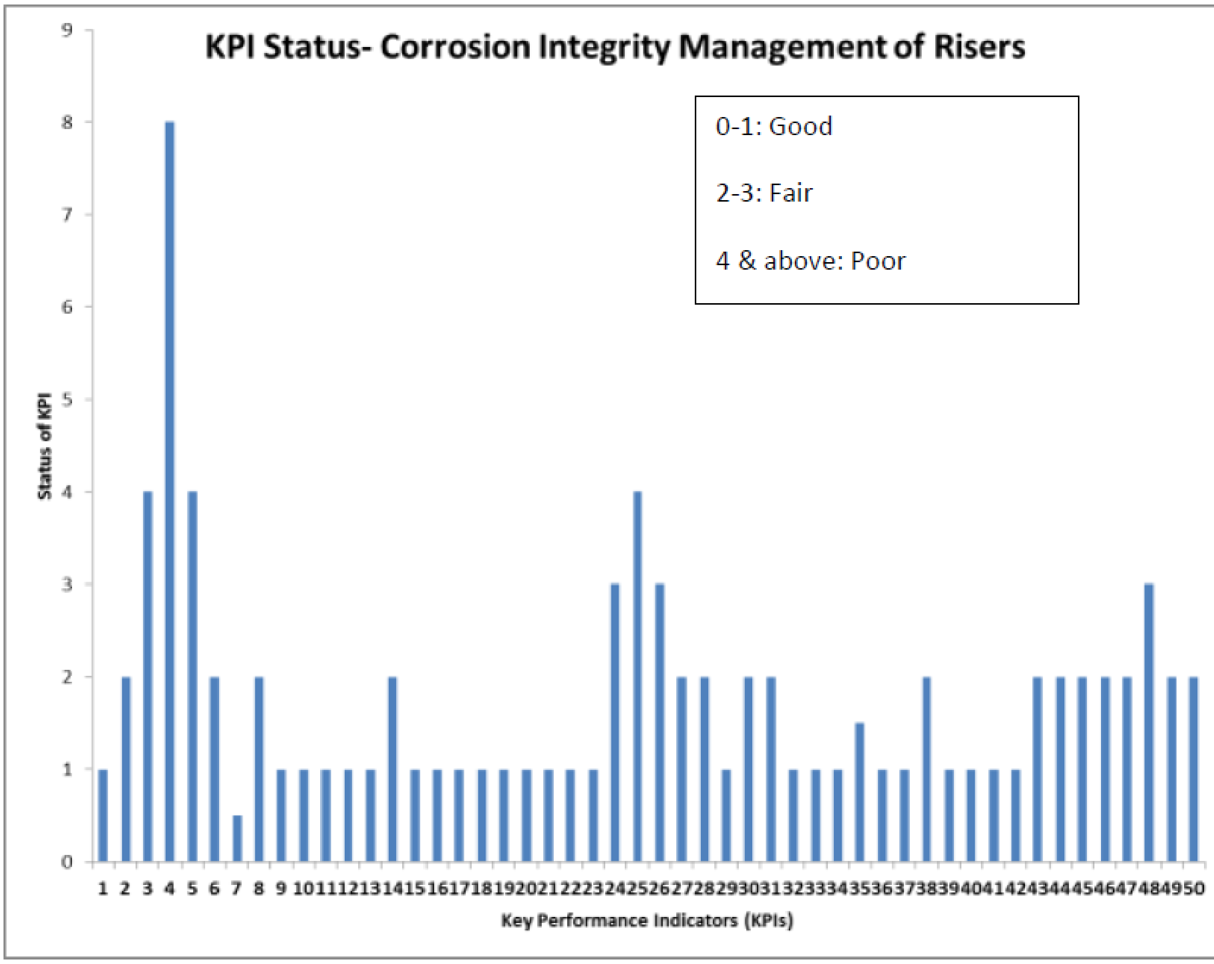

Fig. 2: KPIs Rating for Corrosion Integrity Management of Risers

Table 1: Key Performance Indicators (KPIs) to Develop Effective and Economical Corrosion Control Strategies

KPI No.	KPI description	Status of KPI
1	Segmentation of the infrastructure	Good
2	Corrosion risks	Good
3	Location of the infrastructure	Fair
4	Overall corrosion risk (Risk times consequence)	Poor
5	Life of the infrastructure	Fair
6	Materials of construction	Good
7	Corrosion allowance (wall thickness)	Good
8	Main operating conditions	Good
9	Potential upset conditions in the upstream sector affecting this sector	Good
10	Potential upset conditions in this sector affecting downstream sector	Good
11	Mechanisms of corrosion	Good
12	Maximum corrosion rate (Internal)	Good
13	Maximum corrosion rate (External)	Good
14	Installation of proper accessories during construction	Good
15	Commissioning	Good
16	Mitigation to control internal corrosion	Good
17	Mitigation strategies to control internal corrosion	Good
18	Mitigated internal corrosion rate, target	Good
19	Percentage time efficiency of internal corrosion mitigation strategy	Good

20	Mitigation to control external corrosion – is it necessary?	Good
21	Mitigation strategies to control external corrosion	Good
22	Mitigated external corrosion rate, target	Good
23	Percentage time efficiency of external corrosion mitigation strategy	Good
24	Internal corrosion monitoring techniques	Fair
25	Number of probes per square area to monitor internal corrosion	Fair
26	Internal corrosion rate, from monitoring technique	Fair
27	Percentage difference between targeted mitigated internal corrosion rate and corrosion rate from monitoring technique	Good
28	External corrosion monitoring techniques	Good
29	Number of probes per square area to monitor external corrosion	Good
30	External corrosion rate, from monitoring technique	Good
31	Percentage difference between targeted mitigated external corrosion rate and corrosion rate from monitoring technique	Good
32	Frequency of inspection	Good
33	Percentage difference between targeted mitigated internal corrosion rate or corrosion rate from monitoring techniques and corrosion rate from inspection technique	Good
34	Percentage difference between targeted mitigated external corrosion rate or corrosion rate from monitoring techniques and corrosion rate from inspection technique	Good
35	Measurement data availability	Good
36	Validity and utilisation of measured data	Good
37	Procedures for establishing the maintenance schedule	Good
38	Maintenance activities	Good
39	Internal corrosion rate, after maintenance activities	Good
40	Percentage difference between targeted mitigated internal corrosion rate or corrosion rate from monitoring or inspection technique (whichever is decided in activity 27) and corrosion rate before maintenance activities.	Good
41	External corrosion rate, after maintenance activities	Good
42	Percentage difference between targeted mitigated external corrosion rate or corrosion rate from monitoring or inspection technique and corrosion rate before maintenance activities.	Good
43	Workforce - Capacity, education, and training	Good
44	Workforce - Experience, knowledge, and quality	Good
45	Data management - Data to database	Good
46	Data management - Data from database	Good
47	Internal communication strategy	Good
48	External communication strategy	Fair
49	Corrosion management review	Good
50	Failure frequency	Good