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Corrosion Evaluation of Pipelines in an Oil Production Facility

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Abstract

The corrosion conditions of several flowlines of Eden Yuturi (EY) oil production field of the Amazon Basin in Ecuador in 2017 were previously evaluated. This paper analyses the corrosion conditions of five flowlines between 2017 and 2020.

Budget has been allotted and logically the budget has been adjusted to ensure that the corrosion risk does not increase. This was accomplished by focusing on three main areas: mitigation and monitoring of external corrosion and maintaining knowledge within the company by establishing a global and readily available database. The database will facilitate retrieval of information and hence better management and well-grounded decision making.

1.0 Introduction

The corrosion conditions of several flowlines of Eden Yuturi (EY) oil production field of the Amazon Basin in Ecuador in 2017 were previously evaluated[1].

This paper analyses the corrosion conditions of five flowlines between 2017 and 2020. The underground flowlines are operating under multiphase flow conditions (oil, water, and gas) in an onshore production facility. The pipeline material is carbon steel API 5L grades 42, 65, or 70 and all flowlines are internally and externally coated. Table 1 shows details of five flowlines and Figure 1 presents the network of them.

Table 1 Pipelines included in this assignment

Pipeline	**Pad G – Pad D**	**Pad D – Pad Y**	**Pad J – Pad C**	**Pad F – Pad A**	**Pad A – EPF Line 1**
Length (km)	2.84	4.29	1.21	7.14	3.78
Year Installed	2004	2002	2007	2004	2002
Operating Temp (°C)	85	89	93	93	93
Operating Pressure (kPa)	2,027	1,655	1,689	2,062	1,331
Nominal Diameter (m)	0.457				
Wall Thickness (mm)	7.92				
Product	Multiphase fluid consisting of oil, water, and gas				
Internal Coating	Amercoat 91				
External Coating	FBE				

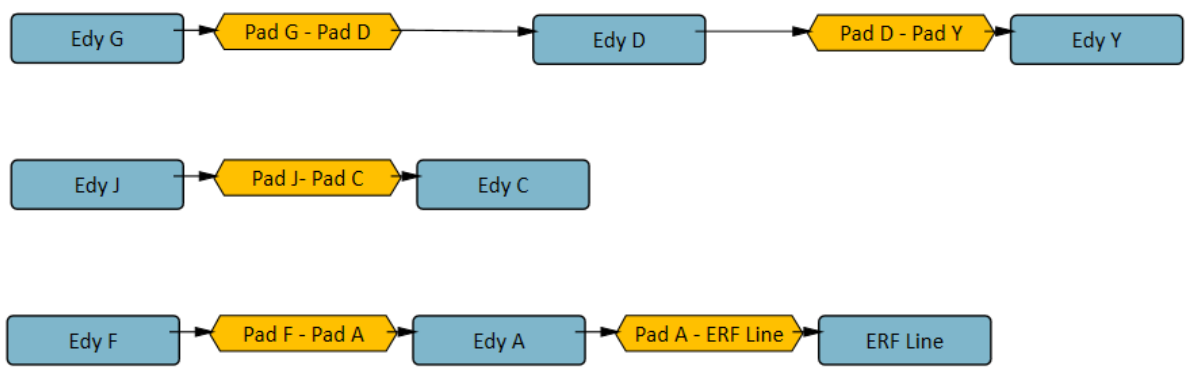

Figure 1 Pipeline network

In the previous review period (installation to 2017), the status of the flowlines was analyzed using fifty (50) key performance indicators (KPI). The preview review identified opportunities for improvement mainly in internal and external monitoring of the asset and recommended some solutions to be implemented to reduce the risk of failure. Table 2 shows the status of the pipeline at the end the previous review period.

Table 2 Current status of the gathering pipelines (Installation to 2017).

#	KPI description		Category	Pad G - Pad D	Pad D - Pad Y	Pad J - Pad C	Pad F - Pad A	Pad A - EPF Line 1
1	Segmentation of the infrastructure		Management	1	1	4	4	1
2	Corrosion risks		Management	3	3	2	3	3
3	Location of the infrastructure		Management	3	3	3	3	3
4	Overall corrosion risk		Management	2	2	1	2	2
5	Life of the infrastructure		Management	4	4	4	4	4
6	Materials of construction	IC*	Model	3	3	3	3	3
		EC**	Model	2	2	2	2	2
7	Corrosion Allowance	IC	Model	4	4	4	4	4
		EC	Model	4	4	4	4	4
8	Normal Operating Conditions		Maintenance	3	3	3	3	3
9	Upset Conditions in the Upstream Segment	IC	Model	1	1	1	1	1
		EC	Model	1	1	1	1	1
10	Upset Conditions in the Downstream Segment	IC	Model	2	2	2	2	2
		EC	Model	3	3	3	3	3
11	Mechanisms of Corrosion	IC	Model	2	2	2	2	2
		EC	Model	2	2	2	2	2
12	Maximum Internal Corrosion Rate		Model	1	1	3	3	1
13	Maximum External Corrosion Rate		Model	4	4	4	4	4
14	Installation of Accessories	IC	Model	2	2	2	2	2
		EC	Model	2	2	2	2	2
15	Commissioning		Maintenance	3	3	3	3	3
16	Internal Corrosion Mitigation		Mitigation	1	1	1	1	1
17	Types of Mitigation Strategies (Internal)		Mitigation	2	2	2	2	2
18	Targeted Mitigated Internal Corrosion Rate		Mitigation	4	4	4	4	4
19	Mitigation Strategy Effectiveness (Internal)		Mitigation	2	2	2	2	2
20	External Corrosion Mitigation		Mitigation	3	3	3	3	3
21	Types of Mitigation Strategies (External)		Mitigation	3	3	3	3	3
22	Targeted Mitigated External Corrosion Rate		Mitigation	4	4	4	4	4
23	Mitigation Strategy Effectiveness (External)		Mitigation	3	3	3	3	3
24	Internal Corrosion Monitoring Techniques		Monitoring	4	4	4	4	4
25	Number of Monitoring Probes (Internal)		Monitoring	4	4	4	4	4
26	Internal Corrosion Rate from Monitoring Technique		Monitoring	4	4	4	4	4
27	Accuracy of Internal Corrosion Monitoring Techniques		Monitoring	4	4	4	4	4
28	External Corrosion Monitoring Techniques		Monitoring	4	4	4	4	4
29	Number of Monitoring Probes (External)		Monitoring	4	4	4	4	4
30	External Corrosion Rate from Monitoring Technique		Monitoring	4	4	4	4	4

#	KPI description		Category	Pad G - Pad D	Pad D - Pad Y	Pad J - Pad C	Pad F - Pad A	Pad A - EPF Line 1
31	Accuracy of External Corrosion Monitoring Techniques		Monitoring	4	4	4	4	4
32	Frequency of Inspection	IC	Monitoring	2	2	4	4	2
		EC	Monitoring	2	2	2	2	2
33	Difference in Internal Corrosion Rate between Monitoring and Inspection Techniques		Monitoring	4	4	4	4	4
34	Difference in External Corrosion Rate between Monitoring and Inspection Techniques		Monitoring	4	4	4	4	4
35	Measurement Data Availability		Monitoring	3	3	3	3	3
36	Validity and Utilization of Measured Data		Monitoring	4	4	4	4	4
37	Procedures for Establishing Maintenance Schedule		Maintenance	4	4	4	4	4
38	Maintenance Activities		Maintenance	3	3	3	3	3
39	Internal Corrosion Rate After Maintenance Activities		Model	3	3	3	3	3
40	Percentage Difference Internal in Corrosion Rate Before and After Maintenance		Model	3	3	3	3	3
41	External Corrosion Rate After Maintenance Activities		Model	3	3	3	3	3
42	Percentage Difference in External Corrosion Rate Before and After Maintenance		Model	3	3	3	3	3
43	Workforce - Capacity, Skills, Education, and Training		Maintenance	4	4	4	4	4
44	Workforce - Experience, Knowledge, and Quality		Maintenance	2	2	2	2	2
45	Data management - Data to Database		Maintenance	4	4	4	4	4
46	Data management - Data from Database		Maintenance	4	4	4	4	4
47	Internal Communication Strategy		Management	2	2	2	2	2
48	External Communication Strategy		Management	3	3	3	3	3
49	Review for Continued Improvement		Management	4	4	4	4	4
50	Failure frequency		Management	1	1	1	1	3

* IC Internal Corrosion

** EC External Corrosion

Table 3 lists the KPIs used to review the status of the pipeline between 2017 and 2020. The status of other KPIs not included in this paper was assumed to be the same as presented in the previous review.

Table 3 Scope of 2017-2020 review period.

#	KPI description	Category
12	Maximum Internal Corrosion Rate	Model
13	Maximum External Corrosion Rate	Model
18	Targeted Mitigated Internal Corrosion Rate	Mitigation
20	External Corrosion Mitigation	Mitigation
22	Targeted Mitigated External Corrosion Rate	Mitigation
23	Mitigation Strategy Effectiveness (External)	Mitigation
27	Accuracy of Internal Corrosion Monitoring Techniques	Monitoring
28	External Corrosion Monitoring Techniques	Monitoring
29	Number of Monitoring Probes (External)	Monitoring
30	External Corrosion Rate from Monitoring Technique	Monitoring
31	Accuracy of External Corrosion Monitoring Techniques	Monitoring
34	Difference in External Corrosion Rate between Monitoring and Inspection Techniques	Monitoring
35	Measurement Data Availability	Monitoring
36	Validity and Utilization of Measured Data	Monitoring
37	Procedures for Establishing Maintenance Schedule	Maintenance
38	Maintenance Activities	Maintenance
43	Workforce - Capacity, Skills, Education, and Training	Maintenance
45	Data management - Data to Database	Maintenance
46	Data management - Data from Database	Maintenance
48	External Communication Strategy	Management
49	Review for Continued Improvement	Management

2.0 Internal Corrosion – Monitoring

KPI 27 Accuracy of Internal Corrosion Monitoring Techniques

Internal corrosion is monitored through coupons installed at several locations and it's the only type of monitoring technique being used currently. Assuming that the coupons are regularly retrieved, results analyzed, and finding correlated with other operations changes, this KPI assumed to be implemented properly.

3.0 External corrosion – Mitigation

KPI 23 Mitigation Strategy Effectiveness

In the previous management review, it was noted that the cathodic protection was accidently disconnected several times temporarily. This can be avoided by periodic monitoring of the system and proper communication especially after any maintenance activities.

4.0 External corrosion – Monitoring

KPI 28 External Corrosion Monitoring Techniques

Several above ground monitoring techniques in addition to ILI should be implemented to reduce the risk of external corrosion. It's recommended to continue monitoring using Cathodic Protection Current Demand (CPCD), Direct Current Voltage Gradient (DCVG), Coating Conductance (CC), & Alternating Current Voltage Gradient (ACVG).

KPI 29 Number of Monitoring Probes (External)

Survey monitoring techniques is recommended to cover a larger portion of the pipeline including all critical and some non-critical areas. The recommended techniques are Close Interval Survey (CIS) and Direct Current Voltage Gradient (DCVG).

KPI 30 External Corrosion Rate from Monitoring Technique

To improve agreement between monitoring techniques a mandatory review meeting between vendors and corrosion professionals to review the data thoroughly.

KPI 31 Accuracy of External Corrosion Monitoring Techniques

A standard procedure for validating the accuracy of the monitoring techniques has been established to verify the precision and the reliability of data by means of statistical analyses.

KPI 34 Difference in External Corrosion Rate between Monitoring and Inspection Techniques

A meeting has been mandated to compare corrosion rates from KPI 28, 29, 30, and 31. The corrosion rate form monitoring technique should be in an agreement with the inspection technique.

5.0 Measurement

KPI 35 Measurement Data Availability

A database to maintain knowledge within the company including the measurement data has been established. The database has been made accessible to all corrosion control team members and should be user friendly.

KPI 36 Validity and Utilisation of Measured Data

A standard procedure for validating the measurement data has been implemented to verify the precision and the reliability of data by means of statistical analyses.

6.0 Maintenance

KPI 37 Procedures for Establishing Maintenance Schedule

The maintenance schedule has been predetermined based on the level of corrosion risk. This risk is evaluated based on KPIs 12, 13, 18, 22, 26. 30, 33, & 34.

KPI 38 Maintenance Activities

The maintenance schedule has been communicated effectively and all players has been asked to follow the schedule as planed.

KPI 43 Workforce - Capacity, Skills, Education, and Training

Ensure adequate number of competent employees to perform the work efficiently. A program has been established to identify areas of improvement and perform training accordingly.

KPI 45 Data management - Data to Database

The database has been established in a global level such that the data from different teams is collected systematically and automatically with minimum human intervention.

KPI 46 Data management - Data from Database

The retrieval process of data from the database has been established in a systematic and in a proactive manner.

7.0 Management

KPI 47 Internal Communication Strategy

The internal communication strategy should be always practiced and documented.

KPI 48 External Communication Strategy

The communication department has been asked to periodically report to external parties and provide information when needed. The effective implementation of internal communication strategy (KPI 47) and the establishment of the database (KPI 45 & 46) will facilitate this task.

KPI 49 Review for Continued Improvement

An annual review meeting has been conducted to discuss and review all corrosion control activities and areas of improvements. The outcome of the meeting and lessons learned has been documented and communicated effectively to all the workers.

8.0 Summary of the Status of KPI and Status of infrastructure (2017-2020)

Based on the establishment of strategies to implement KPI as discussed in previous sections, the risk level in the review period (2017 to 2020) will be at the same level as that in the previous review period (installation to 2017). The percentage of budget to each of these KPI have been identified (Table 3). Further the budget was reduced by 20% so that enough funds are available to implement other KPI described in the previous review period but not discussed in this paper.

9.0 Additional Recommendations

Based on the integrity analysis of this infrastructure, the internal corrosion monitoring techniques should be addressed in the next review period (2020 – 2025) to reduce the corrosion risk further.

10.0 Summary

Corrosion control strategies and their status of several flowlines were established in a previous review period (installation to 2017). In this project, the status of the strategies between 2017 and 2020 was reviewed. Budget has been accordingly allotted and logically the budget has been adjusted to ensure that the corrosion risk does not increase. This was accomplished by focusing on three main areas: mitigation and monitoring of external corrosion and maintaining knowledge within the company through establishing a global and readily available database. The database will facilitate retrieval of information and hence better management and well-grounded decision making.

11.0 Reference

1. *C. Melo, "Key Performance Indicators (KPIs) for Evaluation of Corrosion Control Status in the Gathering Pipelines of an Oil Production Field of the Amazon Basin in Ecuador" (No. 2017–01). CorrMagnet Consulting Inc.* https://corrmagnet.com/wp-content/uploads/2018/01/CMT_2017_01_Carlos-Melo_Paper.pdf

Table 4 Status of the KPI between 2017 and 2020

#	KPI description	Category	Pad G - Pad D	Pad D - Pad Y	Pad J - Pad C	Pad F - Pad A	Pad A - EPF Line 1	Allocated Budget, %	
								%	Reduction of budget
12	Maximum Internal Corrosion Rate	Model	N/A	N/A	3	3	N/A	2%	
13	Maximum External Corrosion Rate	Model	4	4	4	4	4	4%	
18	Targeted Mitigated Internal Corrosion Rate	Mitigation	4	4	4	4	4	4%	-1%
20	External Corrosion Mitigation	Mitigation	3	3	3	3	3	3%	
22	Targeted Mitigated External Corrosion Rate	Mitigation	4	4	4	4	4	4%	-1%
23	Mitigation Strategy Effectiveness (External)	Mitigation	3	3	3	3	3	3%	
27	Accuracy of Internal Corrosion Monitoring Techniques	Monitoring	4	4	4	4	4	4%	-1%
28	External Corrosion Monitoring Techniques	Monitoring	4	4	4	4	4	8%	-2%
29	Number of Monitoring Probes (External)	Monitoring	4	4	4	4	4	4%	-2%
30	External Corrosion Rate from Monitoring Technique	Monitoring	4	4	4	4	4	5%	
31	Accuracy of External Corrosion Monitoring Techniques	Monitoring	4	4	4	4	4	5%	-1%
34	Difference in External Corrosion Rate between Monitoring and Inspection Techniques	Monitoring	4	4	4	4	4	5%	-1%
35	Measurement Data Availability	Monitoring	3	3	3	3	3	5%	-1%
36	Validity and Utilization of Measured Data	Monitoring	4	4	4	4	4	5%	-1%
37	Procedures for Establishing Maintenance Schedule	Maintenance	4	4	4	4	4	4%	-1%
38	Maintenance Activities	Maintenance	3	3	3	3	3	3%	
43	Workforce - Capacity, Skills, Education, and Training	Maintenance	4	4	4	4	4	8%	-2%
45	Data management - Data to Database	Maintenance	4	4	4	4	4	8%	-2%
46	Data management - Data from Database	Maintenance	4	4	4	4	4	8%	-2%
48	External Communication Strategy	Management	3	3	3	3	3	4%	-1%
49	Review for Continued Improvement	Management	4	4	4	4	4	4%	-1%