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Corrosion risk assessment of the oil flow line in Southern Iraq

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***Abstract*---**The risk assessment for three pipelines belonging to the Basra Oil Company (X1, X2, X3), to develop an appropriate risk mitigation plan for each pipeline to address all high risks. Corrosion risks were assessed using a 5 * 5 matrix. Now, the risk assessment for X1 showed that the POF for internal corrosion is 5, which means that its risk is high due to salinity and the presence of CO, H2S and POF for external corrosion is 1 less than the corrosion, while for Flowline X2 the probability of internal corrosion is 4 and external is 4 because there is no Cathodic protection applied due to CO2, H2S and Flowline X3 have 8 leaks due to internal corrosion so the hazard rating was very high 5 and could be due to salinity, CO2, fluid flow rate and water cuts. External corrosion hazard rating 4 is considered high because there is no coating, no cathodic protection is applied.

***Keywords*---**Oil leakage, Risk-Based Inspection (RBI), Likelihood of Failure (LOF), Consequence of Failure (COF).

Introduction

Flow lines carry products which are very critical to the sustenance of country wide economies and continue to be a dependable method of transporting water, oil and gas in the world. Like any engineering facility, petroleum flow lines are subject to specific degrees of degradation and failure. Flow line failures are deadly and disastrous. Spills (e.g., crude oil) can bring about massive, long-lasting environmental problems. Such flow line damage can be due to natural disasters (consisting of landslides, earthquakes), bad maintenance, deliberate or accidents acts of destruction. For example, the 2001 rifle shot with inside the Trans-Alaskan Flow line caused an oil spill of 6143 barrels (258,000 gallons or 976.eight m3) lasting w60 h earlier than repairs. It is consequently essential that they're

successfully monitored for most efficient operation, at the same time as decreasing failures to proper safety limit [1]. The development and implementation of a risk-based integrity management (RBIM) system is vital to maintaining safe and reliable production as production targets increase against the backdrop of inherent time-dependent degradation of the system. Corrosion risk assessment procedure is to provide a standardized approach to flowline risk assessment. Performing flowline risk assessment is critical to improve the current understanding of risk across the flowline network. The intention is to assess flowline risks on a relative basis using qualitative risk assessment such that appropriate risk mitigation can be planned and optimized [2]. The primary integrity threats related to internal and external corrosion, which are responsible for the vast majority of failures in the field. The risk assessments will therefore focus on assessment of these threats as a priority. figure (1-1) (1-2) shows Production rate for wells. corrosion risk assessment will be carried out based on the data available for each flowline.

Figure (1-1)Well X2 Production History

Figure (1-2)Well X3 Production History

Veracity Flowline Risk Assessment Methodology

An overview of the risk assessment methodology is provided below for reference [3]:

- Data collection/review
- Threat identification
- Probability of failure assessment
- Consequence of failure assessment
- Risk evaluation

Data Collection

data for flowlines, including original design data and historical inspection data as well as Flowline attributes (e.g., diameter, wall thickness, material, etc.), Installation condition (e.g., buried, surface laid, above ground, etc.), and Location (e.g., road crossings, populated areas, environmentally sensitive areas, etc.) [4]. table (1.1) shows oil and gas flowlines data.

Table 1-1
data for flowlines

parameter	Value			unite
Flow line	X1	X2	X3	
Commissioning date	2015	1972	2011	
Length	6	2.422	3.381	km
Service	production	production	Production	
Material	API 5L X60	API 5L X60	API 5L X60	
Wall thickness	16.66	10.97	10.97	mm
Nominal diameter	16	6	6-	inch
Co2	2.0	2.0	2.0	mol%
H2s	N/A (0ppm assumed)	N/A (0ppm assumed)	N/A (0ppm assumed)	ppm
Salinity	131500	20000	N/A	ppm
MAOP	139.8	139.8	139.8	barg
Design temp	100	100	100	°C
Operating pressure	21.2	16.5	12.1	barg
Operating temp	84	79	32	°C
Oil flow rate	19757	12643	3.555	bpd
Water flow rate	14402	3161	0	bpd
Gas flow rate	11.7	11	1.904	mmscfd
Coating	Uncoated	Uncoated	Uncoated	

Cathodic protection	commissioning of the CP system in May 2015	not applied	not applied	
Installation condition	Above ground	Under & above	Above ground	
High consequence area	Yes	Yes	Yes	
Ground condition	Dry	Dry	Dry	
Water cut	N/A	84	55	
No.of leak	2	1	10	leaks

Threat Identification

List of threats to be considered in the assessment

Time-dependent

- Internal corrosion
- External corrosion

Time-independent

- Environmental cracking (e.g., H2S-related cracking)
- Mechanical overload
- Equipment failure

threat in this study was internal corrosion and external corrosion (time - dependent)

Probability of Failure

Guidance for assessing the probability of failure for time-dependent and time-independent threats is provided in Table (1-2). Time-dependent threats are assessed based on an estimated remaining life, L, were possible. If a remaining life assessment is not possible, the guidance used to assess time - independent threats may be used. 'Remaining life' should not be taken to be absolute. but estimated remaining life values are a best estimate based on theoretical assessment of the underlying corrosion mechanism(s), the accuracy of which is dependent on the accuracy of input data used in the assessment [5].

Table 1-2
Probability of Failure Guidance

POF Score	Time-dependent	Time-independent
5	L ≤ 0 years	Incident has occurred multiple times on the on the pipeline and/or it is almost inevitable that an incident will occur without additional controls or mitigations.
4	0 < L ≤ 3 years	Incident has already occurred on the pipeline and/or incident will probably occur without addition controls or mitigations.
3	3 < L ≤ 10 years	Common occurrence within the industry and/or has occurred multiple times within Rumaila and/or an incident could reasonably be expected to occur without addition controls or mitigations.
2	10 < L ≤ 20 years	Incident has occurred multiple times in the industry and/or has occurred already within Rumaila and/or a rare combination of factors would be required for an incident to occur.
1	L > 20 years	Incident has occurred before in the industry but there is no history of such failures in Rumaila and/or a freak combination of factors would be required for an incident to occur.

Consequence of Failure

Consequence of failure assessment is performed as per the Flowline Risk-Based Integrity Management Procedure, for each section of the flowline, the consequence of a failure is assessed with respect to the following [6,7]:

- Environment
- Reputation
- Production
- Health and Safety

The guidance for selecting appropriate consequence category in the event of failure is provided in Table (1-3).

Table 1-3
Consequence of Failure Guidance

COF	Health and Safety	Performance	Environment	Reputation
E Major	Multiple Fatalities (3+) >30 Injuries requiring hospital treatment.	> 10 MBD Severe regulatory/ legal enforcement or interventions	Major external incident resulting in long term/permanent damage. Environmental prosecution.	Major interest group outrage Sustained international and national media attention and widespread social impact. Relationship damage with national stakeholders.

D Significant	1 or 2 Fatalities >10 or more injuries requiring hospital treatment	5-10 MBD Severe regulatory/ legal enforcement or interventions	Significant external incident resulting in medium term damage. Stop/ Prohibition Notice issued. Extensive remediation. Potential prosecution.	Significant interest group outrage, short term national media attention. Relationship damage with stakeholders.
C Moderate	Permanent disability DAFWC Several non-permanent injuries	2-5 MBD Moderate regulatory/ legal non-compliance	Moderate onsite incident resulting in short term damage and remediation. Improvement Notice issued.	Prolonged regional media attention. Relationship damage with shareholders and regional community. Moderate disruption to regional operations.
B Limited	Single or multiple recordable injuries or health effects Recordable Medical Treatment or Restricted Work Case	1-2 MBD	Limited onsite incident easily contained. Internal non-conformance. Spill > 10 bbl.	Short term local media attention. Relationship issues with local community. Limited disruption to local operations.
A Minor	First Aid Over exposure but no actual health effects	< 1 MBD	Moderate onsite incident resulting in short term damage and remediation. Improvement Notice issued.	Prolonged regional media attention.Relationship damage with shareholders and regional community. Moderate disruption to regional operations.

Risk Evaluation

Risk evaluation for all flowline has been performed in accordance with the 5*5 risk matrix for corrosion Risk Management, the risk matrix has been reproduced in Table (1-4) for ease of reference [8.9].

Table 1-4
Risk Matrix

Risk matrix		Probability of Failure				
		Very Unlikely (1)	Unlikely (2)	Possible (3)	Very Likely (4)	Probable (5)
Consequence of Failure	Major (E)	13	17	20	25	30
	Significant (D)	8	12	16	19	24
	Moderate (C)	6	8	11	15	18
	Limited (B)	4	5	7	10	14
	Minor (A)	1	2	3	4	9
Key: Very low Low Medium High Very High						

Risk Results and Discussion

For X1

- internal corrosion
  The X1 is understood to have failed on two previous occasions due to internal corrosion. Therefore, the POF is set from 5, where the risk of internal corrosion is very high, which may be due to salinity, the presence of CO2 and the flow rate of the fluids.
- external corrosion
  Significant external corrosion is not expected in the aboveground sections of the flow line. The pipe remains properly supported and not in contact with the soil, and cathodic protection is applied to sections of it. Therefore, the POF is assigned, from 1. Where the ratio of the risk of external corrosion is less than that of internal corrosion [10].

For X2

- internal corrosion
  There was only one failure of this pipe and its causes were not identified and the available data do not indicate that the cause of the failure is internal corrosion, so the POF is set from 4, where the risk of internal corrosion is high, and corrosion can occur in the future due to salinity, the presence of CO2, fluid flow rate and WC.
- external corrosion
  Although the flowline X2 has been installed above ground, there are intermittent burial areas along the path of the flow line based on a review of survey images available on the GIS. The likely cause of the failure is external corrosion.
  As there is no coating present along the length of the flowline and cathodic protection has not been applied to it
  Although the overall corrosion rates are expected to be low, this does not mean that the risk of corrosion is low. So POF is assigned from 4

For X3

- internal corrosion
  Eight out of ten leaks on this flowline were due to internal corrosion, so the POF is set at 5, where the risk of internal corrosion is very high and could be caused by salinity, CO2, fluid flow rate and water cut.
- external corrosion
  The flow line X3 has been installed above ground, since there is no coating along the flow line and no cathodic protection has been applied to it. So, the POF is set from 4, where the risk of external corrosion is high, table (1-5) shows the result of risk evaluation.

Table 1-5
Risk Evaluation

Flowline	Internal Corrosion POF	External Corrosion POF	Consequence of Failure				Risk	
			H&S	Performance	Environment	Reputation	Internal corrosion	External corrosion
X1	5	1	C	E	E	B	Very High	High
X2	4	4	D	E	C	B	High	High
X3	5	4	D	E	C	B	Very High	High

Conclusion

There are very high risks associated with the operation of Flowline X1 and X3 based on internal corrosion, due to the presence of gases ,salts and water cut which produced with oil ,that lead to the occurrence of internal corrosion, while external corrosion has a high probability of occurrence, for flowline X2 the probability of external and internal corrosion is high, many Measures used to stop further external corrosion, eg, installation of a modified cathodic production(CP)system and introduction of appropriate corrosion controls to reduce future internal corrosion, eg, inject corrosion inhibitors

References

1. B. Anifowose, D. M. Lawler, D. van der Horst, and L. Chapman, “Attacks on oil transport pipelines in Nigeria: A quantitative exploration and possible explanation of observed patterns,” Appl. Geogr., vol. 32, no. 2, pp. 636–651, 2012, doi: 10.1016/j.apgeog.2011.07.012.
2. Almashhadani HA, Alshujery MK, Khalil M, Kadhem MM, Khadom AA. Corrosion inhibition behavior of expired diclofenac Sodium drug for Al 6061 alloy in aqueous media: Electrochemical, morphological, and theoretical investigations. Journal of Molecular Liquids. 2021 Dec 1;343:117656.
3. A. W. Al-Mithin, V. Sardesai, B. Al-Harbi, H. S. Murthy, and A. S. A. Hannan, “Risk based inspection (RBI) of aboveground storage tanks to improve asset integrity,” Int. Pet. Technol. Conf. 2011, IPTC 2011, 2011

4. D. Fehr, “Potential benefits of data integration for pipeline integrity management programs,” Can. Int. Pet. Conf. 2008, pp. 1–5, 2018, Doi: 10.2118/2008-015.
5. D. Fehr, “Potential benefits of data integration for pipeline integrity management programs,” *Can. Int. Pet. Conf. 2008*, pp. 1–5, 2018, doi: 10.2118/2008-015.
6. AlMashhadani HA, Saleh KA. Electrochemical Deposition of Hydroxyapatite Co-Substituted By Sr/Mg Coating on Ti-6Al-4V ELI Dental Alloy Post-MAO as Anti-Corrosion. Iraqi Journal of Science. 2020 Nov 28:2751-61.
7. S. Matthews, M. S. Al Jaberi, and D. Mundyath, “Risk based inspection implementation for upstream offshore operator: Case study,” Soc. Pet. Eng. - 30th Abu Dhabi Int. Pet. Exhib. Conf. ADIPEC 2014 Challenges Oppor. Next 30 Years, vol. 3, pp. 1983–1996, 2014, doi: 10.2118/171862-ms.
8. Kadhim MM, AlMashhadani HA, Hashim RD, Khadom AA, Salih KA, Salman AW. Effect of Sr/Mg co-substitution on corrosion resistance properties of hydroxyapatite coated on Ti–6Al–4V dental alloys. Journal of Physics and Chemistry of Solids. 2022 Feb 1;161:110450.
9. F. Bilal, S. Taggert, and N. L. M. Hamata, “Risk assessment for oil flowline ,” south oil company 2018.
10. J. Ballesio, H. Patel, A. Revenga, and P. Rynn, “Risk assessment and technology qualification process for offshore LNG pipelines,” Offshore Technol. Conf. Proc., vol. 5, pp. 2944–2952, 2009, doi: 10.4043/otc-20301-ms.
11. Kustina, K.T., Dewi, G.A.A.O., Prena, G.D., Suryasa, W. (2019). Branchless banking, third-party funds, and profitability evidence reference to banking sector in indonesia. *Journal of Advanced Research in Dynamical and Control Systems, 11*(2), 290-299.
12. Nyandra, M., Kartiko, B.H., Susanto, P.C., Supriyati, A., Suryasa, W. (2018). Education and training improve quality of life and decrease depression score in elderly population. *Eurasian Journal of Analytical Chemistry*, *13*(2), 371-377.