CP Interference … A Failure Analysis

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Abstract

The increasing number of underground gas pipeline has created a challenge for corrosion engineers. To address this challenge, corrosion engineers in a Saudi Aramco facility rely on two main external corrosion mitigation approaches, external coating and cathodic protection (CP). In 2017, a section of piping had severe external corrosion, which had almost never occurred in that facility. The piping underwent an extensive analysis, and the preliminary findings included CP interrupted operation, CP interference, and unforecasted liquid presence around the piping. Two (2) soil samples were sent to the lab for analysis, the result showed higher chloride content around the pipeline. During the analysis, a metal sample was also sent for lab analysis, and the findings were communicated to concur the root cause. The failure also highlighted preventive methods to ensure no reoccurrence in the future for new or existing piping.

Keywords: Failure Analysis. CP Interference. Chloride Content.

Introduction

After maintenance activities at a well site, signs of corrosion were discovered during a walk through activity. The Corrosion Engineering Team investigated and determined that immediate remedial action was required. Upon excavating the buried portion, severe external corrosion was discovered throughout the blowdown line. A root cause analysis took place to identify the trigging factors of the identified severe external corrosion.

This paper summarizes the operational data, discusses the findings, identifies the root causes, and provides approaches to prevent reoccurrence.

The system consists of more than a 1000 gas wells that are distributed over a huge geographical area covering around 140 km^2. Each gas well is equipped with a well head, upstream production spools installed before the pressure control valve (PCV), downstream production spools installed after the pressure control valve (PCV), and a blowdown piping system. It is used during the flaring activities to depressurize the system for maintenance activities. The design conditions for the blowdown piping are shown in Table 1.

Table 1: Design conditions for blowdown piping system

Design Pressure (psi)	Design Temperature (°F)	Length (mm)	Size (inch)	Material	External Coating
1450	230	138000	4	316L SS	APCS-113

Over the past years, all failures and metal loss issues were caused by CO_2 corrosion. CO_2 dissolves in water that accumulates at low profile areas and forms carbonic acid. The acid then attacks the piping. Therefore the focus of the Corrosion Engineering Team was on how to mitigate sweet corrosion.

The current mitigation approaches against corrosion are external coating, cathodic protection (CP), corrosion inhibitor injection system, and clad materials at upstream production spools.

Previously, each wellsite had its own area with no other wells residing close by. With the increasing gas production, well sites are being constructed closer to each other. Moreover, the large number of gas wells and the area of distribution presents new challenges for the Corrosion Engineering Team.

Background and findings

The blowdown piping of the gas well has been in service for over 10 years and never experienced any technical faults. In 2017, and unexpectedly, the blowdown piping had experienced severe external corrosion, requiring total replacement. This type of failure was the first of its kind in the facility.

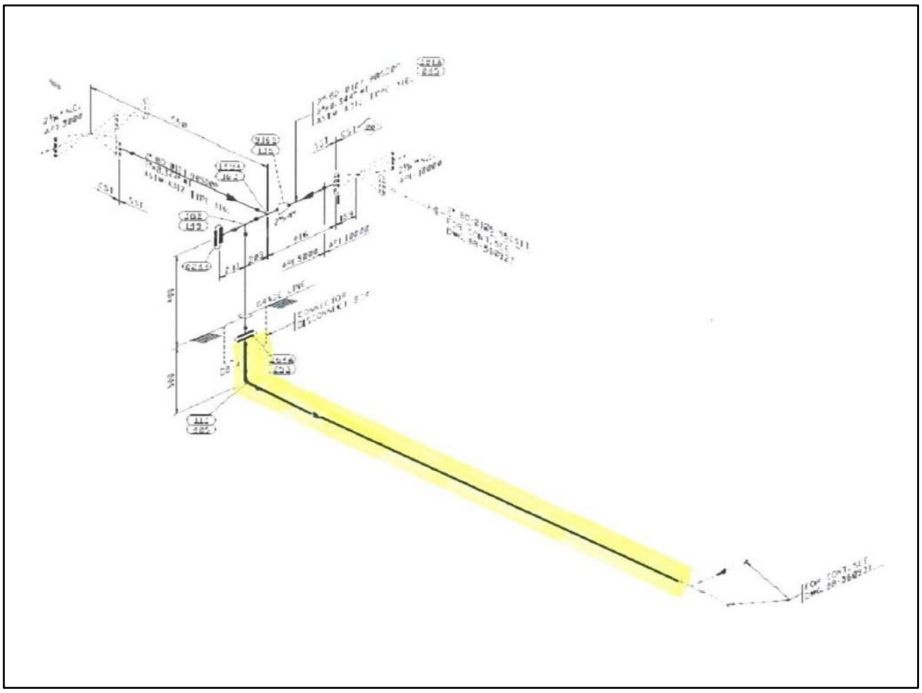

Figure 1: isometric drawing of blowdown piping system

Figure 2: failure of blowdown piping system

Figure 3: failure of blowdown piping system

Figure 4: failure of blowdown piping system

The failed portion underwent an extensive analysis to identify the damage mechanism, and allow the Corrosion Engineering Team to pinpoint the failure's root causes. The analysis comprised a metallurgical examination and a review of the surrounding environment.

Metallurgical Analysis:

Metallurgical examination results revealed that the piping failure displayed signs that resemble pitting corrosion. Different techniques were used to analyze the failed potion externally, as this finding was not satisfactory to the Corrosion Engineering Team. The additional examination has revealed the presence of ferric oxide hydroxide and chloride in questionable amounts.

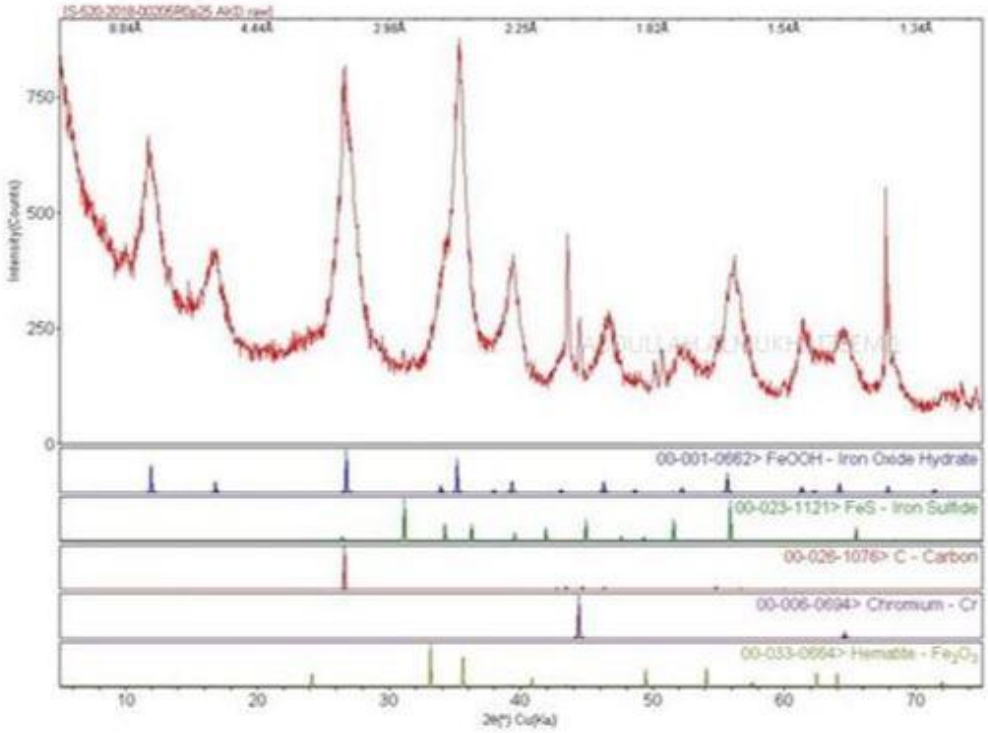

Figure 4: BRD Analysis of the failed piping

The result of the metallurgical examination drove the team to move forward and analyze the soil to validate the result.

Soil analysis:

Two soil samples were collected, one sample was expected to be contaminated (around the pipe) while the other sample is considered to be pure (from the same field but 70m from the corroded pipe). The lab result revealed that the contaminated soil has high chloride content compared to the uncontaminated soil. It was also found that the conductivity of the contaminated soil is more than double compared to the uncontaminated soil. Therefore, high conductivity soil around the pipe is very aggressive due to the low resistivity.

Table 2: Soil Analysis around the failed piping

Sample	PH	Conductivity (µS/cm)	TDS (ppm)	Chloride Content (ppm)
A-Contaminated	7.41	14387	9165	4370
B-Uncontaminated	7.19	6042	3849	1175

Cathodic Protection Survey:

A Cathodic Protection (CP) survey was conducted at the site to evaluate the CP interference susceptibility. The survey showed that X1-378 and X1-530 oil wells are located within a 500m radius from the defective piping. Stray current was identified, which is considered aggressive to buried piping.

Results

The major root causes that increased the corrosion rate include:

- CP Interference due to nearby oil wells.
- Presence of chloride around the buried piping.
- High conductivity around the failed piping.
- Low resistivity around the failed piping.

The blowdown piping was buried in soil with high chloride content, which is considered a corrosive medium for stainless steel. The low resistivity has assisted the CP interference to strongly affect the piping. As mentioned earlier, the blowdown piping is designed to be externally coated using APCS-113. The failure was initiated by improper coating, CP interference, and aggravated by high chloride content around the piping.

Conclusion

The failure was an indicator of another damage mechanism that may occur in that facility. Therefore, the Corrosion Engineering Team moved forward to review the CP system for all areas where wells are located 500m radius, since CP Interference leads to ineffective protection. In addition, the corrosion team focused on the potential sources of chloride that affect stainless steel.

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