

A Case Study on Carbon Dioxide and Microbiological Corrosion Issues in Oil Producing Well Flowlines

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ABSTRACT

In the oil and gas industry, producing flowlines are subject to various corrosion issues due to the presence of various corrosive elements present in the produced fluids. Dissolved CO₂ is an important corrosive element as it causes severe localized corrosion of carbon steel lines. In addition, Microbiologically Induced Corrosion (MIC), which is the impact of microbial presence on internal corrosion can also affect integrity of carbon steel material. In oil and gas industry bacteria can be introduced into surface production facilities during the crude washing process as part of the desalting process. Similarly, secondary recovery by water injection can contaminate the produced fluids typically with Sulfate Reducing Bacteria (SRB). The sudden change in H₂S levels in the produced fluids can be one of the indications of such SRB contamination. Under low flow conditions, bacteria can rapidly proliferate and cause MIC on the carbon steel flowlines/pipelines. The localized corrosion by CO₂ may get aggravated by MIC due to presence of bacteria. Such observations of flowlines will be discussed here.

This paper presents findings based on physical local evidences, fluid data analysis and microbiological testing data analysis and corrosion morphological features.

Key words: Flowlines, corrosion morphology, failure mechanism, reservoir, souring

INTRODUCTION

Oil field operating company's ⁽¹⁾ flowline network in North and West Kuwait (NWK) has over 3000 wells connected through 6" carbon steel pipelines flowing from wellhead to the nearest Gathering Center (GC). Untreated wet crude is transported through the flowlines to GC's directly or passing through the Remote Headers and Manifold (RHM) to GCs. In RHM, mixing of the wet crude takes place before it is sent to GC's via transfer lines for further separation. The flowlines are laid aboveground except at road crossings where they are buried.

Flowlines, some that have been in service for up to 35 years, experienced several leaks due to internal corrosion in the past few years when seawater flooding started in the reservoir to increase the production. In house studies indicated that reservoir souring has occurred most probably due to biogenic reasons and increased levels of gas phase H₂S were recorded at several well locations. In addition, substantial levels of CO₂ were reported in the fluid analyses of the produced crude. Recently several leaks were also reported due to internal corrosion in the new well flowlines producing from this reservoir.

Due to the sudden increase in the internal corrosion leaks in the old and new well flowlines producing from the same reservoir in the recent years, it was requested to carry out failure investigation on leaked flowlines samples and identify the root causes. Simultaneously Long Range Ultrasonic Testing (LRUT) was carried out on leaked sections and low spots of other un-leaked flowlines to check the integrity. Fluid analysis, bacteria testing and deposit analysis was conducted as part of the failure analysis. The findings based on the failure investigation of few of the leaked samples have been presented here. The observed field inspection data and available operational data has also been analyzed and its probable association with the internal corrosion of flowlines has been discussed here.

APPROACH

Fluid data on well samples was gathered from in-house database. Mixed phase fluid velocity was predicted by using available corrosion models. Field inspection of flowlines was carried out by using LRUT technique. Failed samples of five flowlines (FL1 to FL5) were collected from the site and visual inspection was carried out before cleaning, after cleaning, cutting across section and after sweep blasting of sample surface to examine the morphology. X-ray diffraction (XRD) and microbiological analysis of deposits was carried out to detect the corrosion products, phases and microbial counts. Chemical composition and microstructural examination of the few samples was conducted to check for any deviations.

Data Collection

In-house database for the wells fluid data was analyzed and the most stringent (highest recorded value for the last decade) data on water cut, gas phase CO₂, H₂S, dissolved sulfates was tabulated (Table 1). Mixed phase flow velocity was then calculated by using Predict[†] corrosion model. Field inspection by using LRUT was carried out on

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[†] Trade Name

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leaked sections of flowlines and on low spots of other un-leaked flowlines. This was done to check the integrity of flowline, identify the locations/areas of internal corrosion and to decide the pipe length replacement as shown in Table 1.

Table 1
Fluid data, predicted flow velocity and Inspection findings of flowlines

Well/ Flowline No.	CO ₂ in gas phase (mol %)	H ₂ S in gas phase (ppm) (Year of first appearance)	Mixed flow Velocity* (m/s)	Water cut (%)	Sulfate SO ₄ ²⁻ (ppm)	Recommendations Cut & Replace (m)
FL1	2	550 (2013)	0.19	98	2500	500
FL2	2	100 (2014)	0.56	81	NA	Entire line (appx. 1800)
FL3	1.4	20 (2014)	0.37	94	2075	700
FL4	1	12 (2012)	0.50	97	1891	1300
FL5	5	2000 (2017)	0.10	75	2100	Entire line (appx. 3800)

*Mixed flow velocity is calculated using corrosion modelling software. NA: Not available

Detailed Visual Inspection

The figures below show photographs of corroded internal surface of the failed pieces of flowlines before and after sectioning and sweep blasting respectively.



Figure 1: Brown-orange deposit near perforation and thick black loose deposits away from perforation (5 to 7 o'clock) observed on FL1. SRB's were detected in the black deposit



Figure 2: Close-up photograph showing several deep pits surrounding perforation on FL1

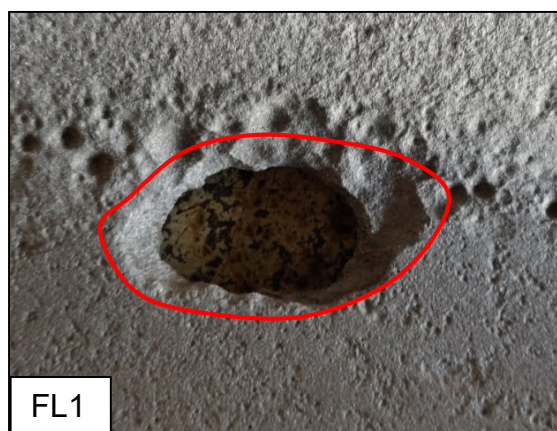


Figure 3a

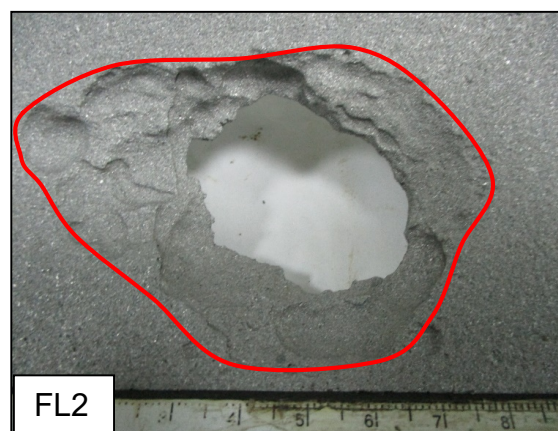


Figure 3b

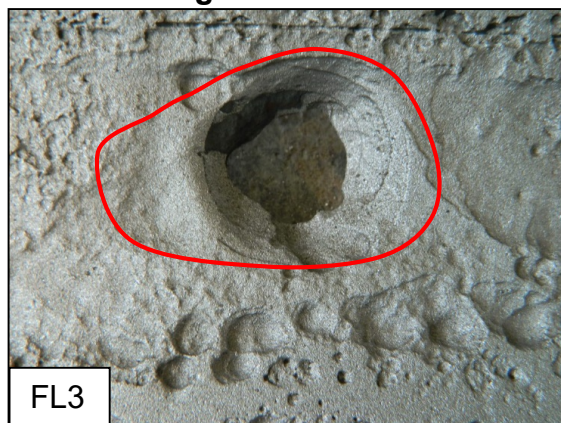


Figure 3c

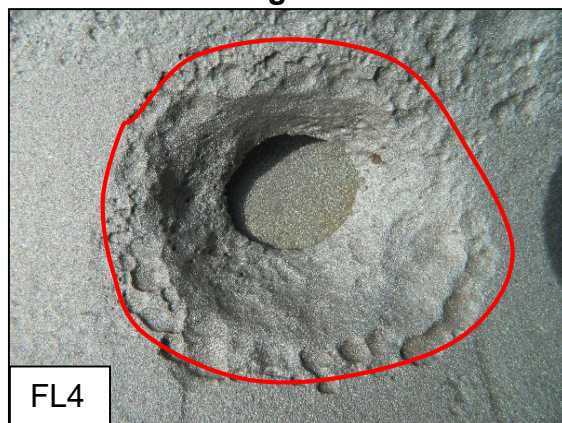


Figure 3d