

Real Time Corrosion Monitoring for High Sour Applications

Dawood Al Sharyani
Petroleum Development Oman
Mina al Fahal
Muscat, PO Box: 81
Sultanate of Oman

Monica Fernandez
Petroleum Development Oman
Mina al Fahal
Muscat, PO Box: 81
Sultanate of Oman

Naveed Munir
Petroleum Development Oman
Mina al Fahal
Muscat, PO Box: 81
Sultanate of Oman

Michael Jones
Emerson Automation Solutions
Dubai, P.O. Box 17033
United Arab Emirates

Hallgeir Jenssen
Emerson Automation Solutions
Stavanger, PO. Box 112
Norway

Kjell Wold
Emerson Automation Solutions
Stavanger, PO. Box 112
Norway

ABSTRACT

The requirement of ensuring the integrity of pipelines in high sour and high-pressure services drives the use of real time corrosion monitoring to achieve an effective corrosion management. In this regards, Petroleum Development Oman (PDO) has used online corrosion monitoring technology to ensure the integrity of carbon steel pipelines transporting high sour fluids with the premise of internal mitigation. The online corrosion monitoring in pipelines has supported PDO's approach as part of overall corrosion management strategy. In this case, Field Signature Method (FSM) technology is used as online corrosion monitoring tool to monitor the metal loss and determine the corrosion rate of the pipelines. In addition, the data from the FSM units can be used to support other studies such as pigging and corrosion inhibitor optimization. This paper will cover the real time corrosion monitoring results with FSM technology and learnings for several pipelines in high sour and high-pressure services.

Key words: Real Time Corrosion Monitoring, Non-Intrusive Technique, Field Signature Method, FSM, High Sour

INTRODUCTION

Corrosion monitoring is the practice of measuring the corrosivity of process fluid conditions and the effectiveness of corrosion barriers by the use of intrusive and/or non-intrusive techniques at most

susceptible locations. PDO developed a new project located in south which have five main pipelines, carbon steel operating at high pressure and high sour conditions.

The Corrosion Management Framework (CMF) includes non-intrusive technique (NIT) with real time data collection to measure the corrosivity of the fluid and effectiveness of corrosion barriers (continuous and batch corrosion inhibitor with routine pigging),¹ whilst reducing the risk of people exposure to high pressure and high sour services. Corrosion monitoring and management for high H₂S applications and underground is also discussed by Wold & Al.²

The selected NIT, to monitor expected corrosion mechanism: localized corrosion due to H₂S corrosion, was Field Signature Method (FSM) located in three points across each pipeline (beginning of the line, middle and at the end) with consideration of low points (see Table 1).

Table 1
Pipeline Details and FSMlog location

Pipeline	Service	Length (Km)	OD (in)	Wall Thickness (mm)	CA (mm)	OP (kPa)	Temp (°C)	Key Point Location (Km)	O'clock position (degrees)
C	Three phase	7.35	18	15.88/17.48	6.0	8375	34.8	0.2 km 3.342 km 6.768 km	360
D	Three phase	4.2	18	15.88/17.48	6.0	8183	33.8	0.174 km 2 km 3.6 km	360

NON-INTRUSIVE TECHNOLOGY

Field Signature Method (FSM) is based on feeding a current pulse (in the range of 10 A to 50 A with a pulse length from 1000 ms to 7000 ms) through a selected section of the pipeline to be monitored and sensing the electric field pattern by measuring small potential differences between a set of sensing pins (matrix) installed on the external pipe wall. Therefore, the corrosion is measured between the sensing pins as well as under, which covers the full area of the matrix.

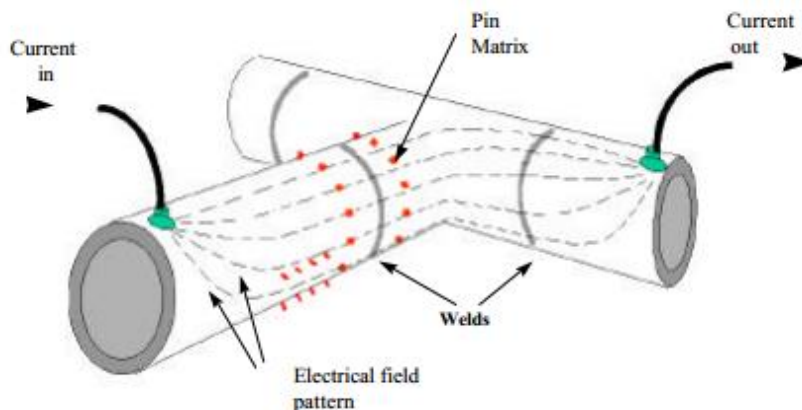


Figure 1. Electrical field pattern created across the pin matrix

This technique evaluates the metal loss on the steel according to the Ohm's law ($V=IR$). This law states that the current (I) through a conductor (resistance of the conductor, R) between two points is directly proportional to the voltage (V) across the two points which in case of having damage or corrosion on the steel electrical resistance will be increased at that area. Since the resistance of the steel is a

function of temperature, FSM uses a reference plate to compensate for small temperature variations (2 to 3 degrees). If there are larger temperature variations, then the software has an additional temperature compensation function that can be used.

The initial measurement (Field Signature) is unique to the geometry of the pipeline and measures the voltage drop between all pairs of sensing pins. When general or local corrosion occurs the pattern of the electric field will change and can be compared with the signature.

By proper interpretation of the changes in the potential differences, it can be further identified general corrosion as a uniform increase in voltage drops between all pin pairs, and localized corrosion as a local increase in the values.

This technique therefore identifies both general and localized corrosion, with a detection sensitivity of 0.1% of pipe wall thickness for general corrosion. For localized corrosion, the attack must have a volume loss that gives a change of 0.1% in the electric field between two sensing pins to be significant. Quantification of a localized attack with respect to shape and depth may be challenging, however, the technology provides unique information about location and development of localized attacks.

The software capabilities allow to plot the data in different ways: i) metal loss versus time or ii) 3D plots that show the distribution of corrosion over the monitored area. It also contemplates variables that allow to determine the proper unit functionality, such as current feed, temperature sensors and supply voltage.

PDO has installed FSM units with two different modes of communication across the years: i) FSM-IT (off-line, download monthly) during 2004 and ii) FSM-log (on-line, real time data) most recently within the new high sour projects.

LONG TERM DATA FROM LEGACY OFF-LINE SYSTEM

Figure 2 shows the legacy system configuration (FSM-IT, off-line) configuration. With this system, several monitoring locations were covered by one portable meter for making measurements on a periodic basis. The benefit of the solution was reduced cost per location, one instrument could cover multiple locations. The disadvantage was that personnel had to visit each site for every measurement to be made, which added to operational cost. Also, with manual measurements, measurement frequency was lower, and short term trending more difficult due to few data points.

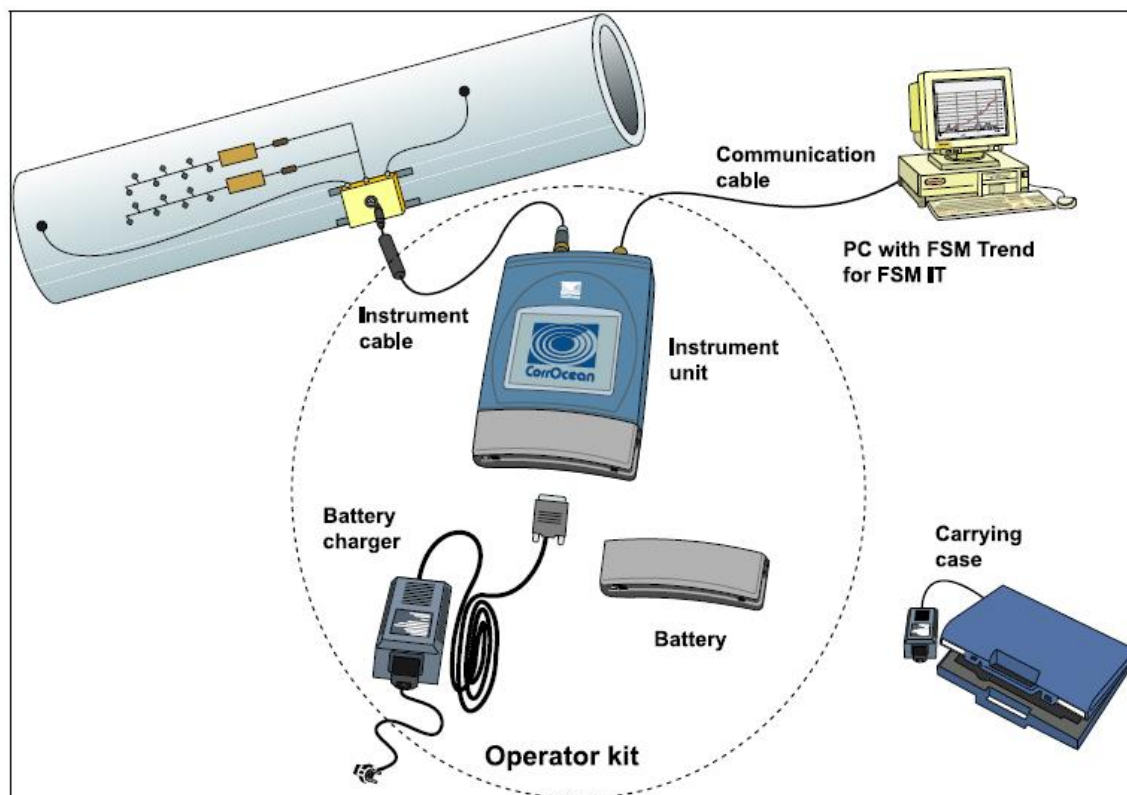


Figure 2: FSM-IT (off-line) configuration – One portable instrument used to collect data from FSM-IT sensing pin matrices at multiple underground locations

PDO has more than 20 FSM-IT units allocated in multiphase pipelines. Below example from legacy application software showing off-line FSM-IT unit results (period 2004 till 2017) located in one pipeline.

Figure 3 shows average metal loss versus time for the monitored location, whereas Figure 4 shows the highest metal loss location (bottom of pipe) versus time for the same period.

A “ruler function” has been used to establish the overall corrosion rate over the period, which was assessed to be in average 0,005 mm/y (Figure 3), and a highest corrosion rate of 0,009 mm/y bottom of pipe (Figure 4).

It can also be seen that corrosion was higher in the period 2007 – 2008, but even in that period, metal loss was less than 0,1 mm. This means that both corrosion rate values are well within the Company criteria (corrosion rate ≤ 1 mm/y).

Furthermore, the process estabilizes after 2008, with a clear indication of corrosion control barrier compliance.