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Corrosion Monitoring

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Recent Developments in Corrosion Monitoring and Applications for Africa

Corrosion is a major threat to the integrity of assets in the oil and gas industry today – both upstream in offshore production and downstream in refineries.

This is particularly the case in Africa where, with many pipeline and refinery assets aging and operators focusing on optimum production strategies, pipeline integrity and accurate corrosion monitoring has rarely been more important.

Kenya's Energy Ministry Permanent Secretary, Patrick Nyoike admitted as much recently in the decision to upgrade the Mombasa-based Kenya Petroleum Refinery admitting that "every once in a while, we have had major ruptures, due to age, fatigue and corrosion," (*Reuters*).

There are a variety of reasons behind corrosion.

Crude oil and natural gas often contain potentially corrosive impurities. Furthermore, metals immersed in conductive mediums can result in electrochemical corrosion and the differences between casing joints and changes in fluid compositions can also lead to corrosion. In refineries, different types of corrosion may take place, such as naphthenic acid corrosion.

In upstream oil and gas production, corrosion is mostly related to the presence of water, carbon dioxide (CO_2), and hydrogen sulphide (H_2S).

The presence of saline water for example, can cause scaling, hydrates and corrosion, and in wet gas fields, such as found offshore Algeria and Egypt, corrosion is mainly caused by the presence of CO_2 in the gas and water breakthrough. Fields with high H_2S concentrations – sour service environments – can also have a negative impact on the infrastructure.

Finally, there is the issue of sand with sand erosion often contributing to corrosion in general due to particles removing deposits or protective layers on the metal surface. According to the Senergy Group, today some 70% of the world's oil and gas reserves are contained in sandstone reservoirs where sand is likely to become a problem at some point during the field's lifecycle. In addition to the erosion and corrosion mentioned above, sand can also directly erode completion components, impede wellbore access, and interfere with a wide variety of oil and gas infrastructure.

And whatever the source of the corrosion, the results can be devastating. Offshore corrosion can lead to production losses, metal losses, or safety and environmental setbacks. In refineries, the corrosion of key infrastructure can have a significant impact on both the economics of the refinery process and the safety and maintenance of the plant.

It is against this context that it has never been more important to deploy accurate, effective and cost efficient corrosion monitoring technologies – vital in preventing corrosion damage and unplanned production stops, leaks, and accidents.

With a particular focus on offshore, upstream operations, this article will examine some of the latest corrosion monitoring technologies on the market and how they are meeting today's corrosion challenges in Africa. The article will specifically look at developments in the use of wireless in corrosion monitoring.

Intrusive Corrosion Monitoring

The most common form of corrosion monitoring over the past few years has been internal, intrusive corrosion monitoring.

Intrusive corrosion monitoring can consist of test and weight loss coupons, where corrosion is determined from the weight loss over a period of time; electrical resistance (ER) probes, and linear polarization resistance (LPR) probes. These coupons and probes are placed within flow lines, process piping, or import and export pipelines – both topside and subsea.

Common for all these methods, except weight-loss coupons, is a high resolution and an ability to respond fast to changes in corrosion rates – something that is particularly useful for corrosion inhibitor programs.

One of the traditional limitations of intrusive monitoring methods, however, are the issues of retrieval, accessibility and installation costs, especially the case in offshore, deepwater fields, such as offshore West Africa. In such circumstances, unless they are installed topside, retrieval can be a significant issue.

There are also potential limitations in that the corrosion on the probe does not necessarily reflect corrosion at the pipe wall, leading to a reduced inability to detect localized attacks, such as pits or weld corrosion.

With these issues in mind, there has been an increased focus on non-intrusive corrosion methods which can be directly installed onto the pipe.

Electric Field Signature Measurement (FSM)

One of the most sensitive and accurate forms of non-intrusive corrosion monitoring today is electric field signature measurement (FSM) technology.

Already referenced in previous articles, FSM, which can be used in subsea pipelines and flowlines, underground pipelines, process piping, and high temperature applications, is a non-intrusive method for monitoring corrosion, erosion, and localized attacks.

By inducing an electrical current into strategically located pipe sections, the current creates a pattern determined by the geometry of the structure and the conductivity of the metal. Voltage measurements on each pin pair (up to 384 pins can be applied in pairs in a matrix) can then be compared to the 'field signature.' In this way, graphical plots can be generated, indicating the severity and location of the corrosion, thereby calculating corrosion trends and rates.

For applications where space is important, where there is a need to operate at high temperatures, and where the requirement is for the best coverage of localized corrosion, non-intrusive corrosion is today delivering significant benefits to the operator.

The Move Towards Online Corrosion Monitoring and a Smart Wireless Asset Management System

Online corrosion monitoring is key to both intrusive and non-intrusive monitoring today, allowing for more frequent data collection, improved data and accuracy, and making the correlation with other process parameters easier to carry out.

To reflect operator demand, we have introduced online and real-time corrosion monitoring to FSM. Today, Emerson's corrosion monitoring systems include an online data logger which can be used with a wide range of wireless communications solutions, and data can be also transferred online from intrusive corrosion probes, such as ER, LPR, and galvanic probes.

Yet, it is not just non-intrusive systems that are going online. Corrosion monitoring is being taken further through a smart wireless asset management system which is being developed for intrusive sensors in both corrosion and sand monitoring *(see Figure 1).*

Figure 1

These wireless technologies will reduce the cost and threshold for online corrosion monitoring, and can be integrated both with the combined corrosion monitoring system and other wireless monitoring applications within the same wireless mesh.

The Roxar CorrLog & SandLog Wireless transmitters in *Figure 1* will consist of corrosion wireless transmitters that can be used both upstream and downstream. They combine Emerson's Smart Wireless technology with Roxar corrosion instrumentation to provide a complete wireless integrity management solution for protecting operators' assets.

The transmitter-based systems are based on intrusive sensors that are installed into pipes or vessels through an access fittings system. Access systems are divided into low pressure systems, such as retractable probes often used in refineries or chemical plants, and high pressure subsea systems.

Key features include direct integration to a *Wireless*Hart™ network, high accuracy and sensitivity (28 bit resolution, actual accuracy from 10-100 ppm of probe element thickness), a 20-meter cable between the probe and transmitter allowing for more convenient installation and maintenance, the optimizing of the routing of the wireless signal, and the ability to function at an operating temperature of -40^{o}C to $+70^{o}$C (-40^{o}F to 158^{o}F).

The result will be a significant reduction in installation costs compared to wired online systems (a recent study by Emerson found that installing wireless along with other technologies in the process control system can save up to 7%, or more than $1 million); increased accuracy and reliability with a low risk of signal loss in high risk applications; better data and trending; and monitoring in previously inaccessible areas.

In this way, the new system is addressing many of the traditional weaknesses of intrusive sensors, mentioned earlier in the article.

A Single Asset Management System

The Roxar CorrLog & SandLog Wireless transmitters are just one element of a complete asset integrity system with direct integration through the Smart Wireless Gateway and access to Roxar Fieldwatch, Emerson's Windows-based field monitoring system, for advanced data analysis.

Probes can be read from other manufacturers and the direct transmission of metal loss values, for example, can be fed into the field monitoring system for improved monitoring and analysis.

Monitoring data from a wide variety of monitoring solutions can also be handled through the same software and hardware. For example, traditional corrosion monitoring, acoustic sand monitoring, FSM, and acoustic pig detectors can all be provided within one integrated system. Here the same infrastructure (cabling, cabinets, software, etc.) can be used across all monitoring functions, thereby reducing costs.

The data analysis software interface supports several types of instruments, including intrusive corrosion and sand/erosion probes and the FSM system. With FSM, for example, the system can include a detailed view of all pin pairs and a full 3D view of corrosion and erosion, in addition to configuration and diagnostics tools. Metal loss as a result of a localized attack can also be viewed in real-time.

The latest version of Emerson's field monitoring system (*Figure 2*) also comes with new features in the areas of sand erosion control which can have a direct impact on corrosion.

This includes new smart alarm software consisting of a new filtering and temperature compensation algorithm that assesses how trustworthy each sand erosion measurement is, and the ability for operators to deploy virtual erosion sensors within their production system. This is particularly to monitor bends, T-bends, and reducers in areas where it's difficult to deploy physical sensors. While not as accurate as real sensors, the virtual erosion models can calculate important production information by inputting flow information, pressure, and temperature data.

We all know how important it is for operators to protect the integrity and extend the life of their downstream and upstream assets, and we also know that the age-old threat of corrosion remains a significant obstacle to African operators in guaranteeing the successful flow of hydrocarbons from refinery to reservoir.

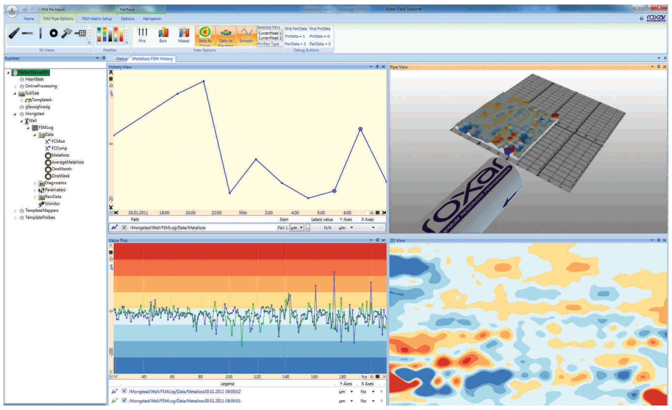

Figure 2

By bringing greater intelligence, integration and wireless technology to both intrusive and non-intrusive corrosion monitoring, African operators will be in a much stronger position to combat such challenges.