

**DRAFT**

# The electric field

Kjell Wold, Emerson Process Management, Norway, discusses technological improvements in electric field signature monitoring.

**T**here is no doubt that internal and external corrosion are a major challenge in pipeline integrity management today. With many pipeline assets ageing and operators focusing on effective production strategies to accelerate cash flow, pipeline integrity and the need for accurate corrosion and erosion monitoring of large surface areas have never been more important.

Production losses, metal loss (which reduces the life of production and storage equipment), or safety and environmental setbacks, due to the corrosion of key infrastructure, are simply not an option for today's oil and gas operator.

Many operators have been addressing these challenges through internal corrosion monitoring, particularly at the midstream level in refineries. Such monitoring has led to more efficient corrosion control where corrosives vary from batch to batch and where corrosion control is critical with respect to integrity, maintenance and economic performance.

The same is the case upstream where internal monitoring has been implemented on oil and gas production installations both





**Figure 1. Sensing pins welded to the external pipe surface as part of an FSM installation in Brazil.**



**Figure 2. An offline electric field signature system on an underground pipeline in Brazil.**

topside and subsea. Whether they are placed within flowlines, process piping, or import and export pipelines; internal corrosion monitoring and its wide variety of equipment (corrosion monitoring test coupons, electrical resistance (ER) probes, and linear polarisation resistance (LPR) probes) have become crucial to operators.

### The rise of non-intrusive monitoring

In addition to the more intrusive probes and coupons, non-intrusive corrosion methods that can be directly installed on the pipe have become increasingly attractive to operators.

Corrosion is often most severe at the bottom section of the pipeline because this is the location where water is most likely to be present. Monitoring such locations with

traditional probes requires access to the bottom of the pipe, which would require big pits under the pipeline with space for access fittings and space for operating retrieval tools.

Non-intrusive corrosion has also become particularly popular in sour production ( $H_2S$ ) environments, where direct measurements at the pipe wall can give more reliable measurements and where safety is a concern for probe retrieval operations. With intrusive monitoring, a conductive FeS (iron sulfide) film can be deposited on the probe surface or can cause electric contact between the probe elements and metallic parts of the probe body, causing erroneous and unstable measurements.

Refineries are also benefitting from non-intrusive monitoring, where the probes can be directly installed on high temperature pipes and where crudes can have different corrosive properties making it all the more important to protect the plant's integrity.

For any application where space is important and where direct measurement on the pipeline provides monitoring and safety advantages, non-intrusive corrosion has become a popular alternative to traditional internal methods.

### Electronic Field Signature Monitoring (FSM)

One of the most popular non-intrusive monitoring techniques is electric field signature monitoring (known by Roxar as CorrOcean FSM). The Roxar CorrOcean FSM is a non-intrusive method for monitoring corrosion, erosion or localised attacks/cracks inside pipelines, process piping or vessels. FSM can be used in subsea pipelines and flowlines, underground pipelines, high temperature applications in refineries, applications in sour (high  $H_2S$ ) service environments, or in process piping and pipelines.

FSM, which has been on the market since the early 1990s and is available topside and subsea, is based on feeding a current through a selected section of the structure to be monitored and sensing the electric field pattern by measuring small potential differences set up on the surface of the monitored object. This is achieved through non-intrusive sensing pins, which are distributed over the areas to be monitored and detect changes in the electrical field pattern. Voltage measurements are then compared to the 'field signature', which provides the initial reference.

By inducing an electrical current into strategically located pipe sections, changes in the electrical field pattern can be monitored and conclusions can be drawn relating to the general wall thickness, and the slightest initial signs of metal loss, through uniform and localised corrosion, can be identified at an early stage.

The induced electric current in a pipe wall creates a pattern determined by the geometry of the structure and the conductivity of the metal. This pattern is represented by current flowlines and equi-potential lines, which are normal to the current flow. The subsequent potential measurements on each pin pair (up to 400 pin pairs can be applied in a matrix) are compared to the unique field signature and the changes processed to define the change in pipe wall over time.

Figure 1 shows the installation of FSM, non-intrusive monitoring in Brazil where the sensing pins are welded to



**Figure 3. An online instrument onsite at an Indian refinery.**

the external pipe surface, the instrumented pipe section is protected externally by a polyurethane compound, and the soil is then put back into position with interface boards and connectors (installed on a post) the only permanent components above ground.

The ability to distinguish localised attacks and general corrosion in real-time as well as detect corrosion rates much earlier than traditional corrosion methods (allowing corrective action to be taken before damage occurs) is crucial to operators as they look to guarantee real-time flow assurance.

To reflect operator demand, online and real-time corrosion monitoring to FSM has been introduced. The online system and new, online data logger can be used with a wide range of wireless communications solutions (radio, telephone, GSM, satellite phone) as well as being powered through solar panels.

## FSM in refineries

Non-intrusive corrosion monitoring and FSM systems have become an important part of refineries' systems for optimising production and guaranteeing integrity management.

Figure 3 shows installed sensing pins with field cables and termination in an online instrument on-site at an Indian refinery.

## Recent improvements in FSM methods – data management

The last 15 years have seen significant improvements in FSM technology. The development of the new FSMLog system is a good example, providing improved accuracy combined with an affordable cost.

There is a key area, however, where Emerson Process Management is taking FSM technology forward even further – data management.

FSM measurements generate a considerable amount of data - extensive information about corrosion rates and distribution. This has been exacerbated through the growth of online systems, which generate more frequent measurements.

As well as the increase in data, there has also been a general trend among operators to more integrated monitoring systems that include not only intrusive and non-intrusive

erosion monitoring, but also sand monitoring, pig detection and other downhole measurements. This, in turn, has resulted in an increase in users among the asset team who wish to access such a system.

Against this context and the need to better manage, organise and interpret the data, Emerson Process Management has developed a new data management software solution to support non-intrusive corrosion monitoring and, in particular, FSM methods.

Specific data management features include multi-user functionality with many users able to work simultaneously; fast data handling with real-time information available to all users; new data formatting; and an integrated, step by step software workflow, which follows the product from system engineering through to data management and reporting.

Such a workflow includes the design and definition of the sensing pin matrix design in the programme; the direct provision of technical documentation for the sensing pin matrix design; a service console for use by the service engineer during installation and commissioning for set-up, diagnosis, checking and verification; the receipt of data for data storage, analysis and reporting; and alarm facilities.

Finally, integration with other corrosion monitoring and sand/erosion monitoring remains crucial with the software built on the same platform.

Such an integrated and easy-to-use workflow is crucial for effective corrosion monitoring today and particular the FSM method. It allows knowledge to be captured and best practices to be shared across the asset team; it provides intelligent software to help the user capture and interrogate data and automate simple tasks; and it helps increase productivity and ensures an effective pipeline integrity strategy.

Integration can also lead to more effective reservoir management with corrosion monitoring working side-by-side with sand sensors, wet gas meters and other downhole tools measuring pressure and temperature. In the ideal world, the operator, through a combination of instrumentation and software, can monitor production continuously, observe and control fields from remote locations, and make immediate decisions to face down production threatening problems – for example, the introduction of a corrosion inhibitor.

## Conclusion

FSM monitoring has become a widely accepted technology for corrosion monitoring; particularly for applications with high temperatures, sour environments, underground pipelines and subsea pipelines/flowlines. New developments have also resulted in improved accuracy and FSM systems at a cost affordable for the monitoring of a larger numbers of monitoring locations.

Important improvements in data management software will add to the reliability and resolution of localised attacks in all directions and improve data management and the reporting of field data in the future. **WP**

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