The challenges OF CORROSION

Kjell Wold, Emerson Process Management, Norway, examines the different variables behind corrosion in the oil and gas sector and reviews how these challenges are being addressed.

Corrosion and material degradation is one of the biggest challenges in the upstream, midstream and downstream oil and gas sectors.

From the dangers of increased water production upstream (necessitating the injection of corrosion inhibitors) through to corrosion in cooling water systems, flare systems or distillation units at the refinery, corrosion is a continuous cost and drain on resources. It can also have a major impact on the

Figure 1. Emerson`s Roxar CorrLog Wireless transmitter for ER and LPR probes.

cost effective flow of hydrocarbons from reservoir to refinery.

Another major area of corrosion is between the reservoir and the refinery in the long distance pipelines that characterise so many onshore and offshore fields today. In such cases, the real-time flagging of corrosion issues to ensure that effective remedial action is taken immediately – without any negative impact on pipeline flows – is vital.

Key factors behind corrosion

Many factors can have an impact on corrosion. Age, original construction specifications and pipeline processes can vary significantly as can the different pipeline materials being used. In upstream oil production and in the pipeline flow from reservoir to refinery, corrosion is also often related to the presence of water, carbon dioxide (CO_2), and hydrogen sulphide (H_2S).

In refineries, corrosion might also include general corrosion in carbon steel lines and vessels; localised corrosion in stainless steel units; or naphthenic acid corrosion in high temperature distillation units and transfer lines. In addition, changes in operational temperature and velocities can also influence plant performance and pipeline corrosion.

It is clear that in all cases the results can be devastating with a highly negative impact on the economics of the upstream, midstream and downstream processes, potential obstructions to flow, as well as concerns over the safety and maintenance of infrastructure and personnel.

Intrusive corrosion monitoring

One of the most common corrosion monitoring technologies today are intrusive probes and coupons. In pipelines and upstream oil and gas production, high pressure retrievable style probes are most commonly used, whereas a retractable style probe is more common in refineries. In particular, there are weight loss coupons, electrical resistance (ER) and linear polarisation resistance (LPR) probes. Figure 1, for example, shows Emerson's CorrLog wireless corrosion transmitter for ER and LPR probes.

Weight loss coupons are the simplest devices for intrusive corrosion monitoring. Pre-weighed steel samples are inserted into the pipe or vessel for a given period, then cleaned and weighed after retrieval. Based on the weight difference, corrosion rates, deposits and the tendency to localised attacks on the exposed coupon are calculated and reported.

LPR probe measurements are based on calculating the current response to a small polarisation of the probe's working electrode in a 2- or 3- electrode configurations. The corrosion rate is proportional to the current response measured, and utilisig theoretic and empiric factors, corrosion rates can be determined from only one measurement. Other electrochemical methods like electrochemical noise may also be applied in pipeline corrosion monitoring. However, a limitation with electrochemical methods is that they require a water phase in order to give good data.

ER probes are based on measuring changes in the resistance of the probe's measurement element. As the metal element corrodes, the thickness is reduced and the resistance increases. Reference elements inside the probe are used to compensate for temperature fluctuations.

The advantages of ER probes are that they have a high resolution (down to tens of nanometres of metal loss) and are hence able to respond to changes in corrosion rates quickly. The probes can also be used in most environments (oil, gas and water) and are available with a high temperature rating. Intrusive probes can actually detect corrosion rates changes and enable corrective actions to be implemented and verified before such rate changes have even been detected by non-intrusive systems.

In summary, due to their high resolution and fast responses, intrusive probes are important for active corrosion management as well as the verification and optimisation of corrosion inhibitor use and facilitation of oil and gas flow.

The benefits of non-intrusive monitoring

For all the benefits of intrusive monitoring, however, measurements are still local. The probe is therefore most likely to be useful if the corrosion is uniform. It is often difficult, however, to pick up localised corrosion attacks, such as pits or uneven forms of corrosion experienced in naphthenic acid corrosion.

In addition, 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 (often at low spots of the pipeline). Monitoring such locations with traditional probes necessitates access to the bottom of the pipe, requiring big pits under the pipeline and space for access fittings and operating retrieval tools.

It is with these limitations in mind that non-intrusive corrosion methods, directly installed on the pipe, have also become attractive to operators. One of the most popular non-intrusive monitoring techniques is electric field signature monitoring (FSM).

Field signature measurements

Field signature measurement (FSM) corrosion monitoring is a non-intrusive method for monitoring corrosion, erosion, or localised attacks.

FSM is based on the feeding of an electric current through a selected section of the structure to be monitored. This is achieved through non-intrusive sensing pins distributed over the areas to be monitored.

By inducing an electrical current into strategically located pipe sections, the induced electric 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 a matrix) can then be compared to the 'field signature' that provides the initial reference, and changes in the electrical field pattern can be monitored. Conclusions can then be drawn relating to the general wall thickness and the initial signs of metal loss.

FSM's ability to distinguish localised attacks and general corrosion in real-time as well as the ability to detect corrosion rates much earlier than traditional corrosion methods is a significant benefit. This allows corrective action to be taken before any damage occurs.

Furthermore, in response to operator needs for real-time measurements, Emerson has also introduced an online system and online data logger used with a wide range of wireless communications solutions.

The result is higher data collection frequencies, thereby increasing the accuracy of the system; and an online system that allows remote and wireless data communications direct to the operators' offices.

Applications across the industry

Today, intrusive and non-intrusive corrosion monitoring are being seen in all areas of the oil and gas sector – upstream, midstream and downstream – and are being used worldwide to detect corrosion in a wide range of critical pipeline applications and facilitate flow.

In the Jamnagar refinery in India, for example, the Roxar FSM is helping the operator visualise localised corrosion in 3D format and providing metal loss in detail. The results illustrate how FSM can monitor and control high temperature corrosion accurately and efficiently, optimise production, and guarantee integrity management. The FSM online systems used in Jamnagar has a resolution within the range of 0.1% of the wall thickness.[1]

Emerson has also secured a number of repeat orders for land-based field development corrosion monitoring projects in East Asia that combine non-intrusive and intrusive monitoring. For those repeat orders, Emerson provided corrosion monitoring systems to track corrosion in surface pipeline gathering facilities in a high H_2S environment.

The system consisted of corrosion coupons, ER and LPR probes, and corrosion monitoring/data collection communications systems – all helping the operator track any incidents of hydrogen induced cracking. A central element of the system was also the non-inserted Roxar FSM online system.

As well as the monitoring solutions, injection systems based on hydraulic access fitting connections were included in the deliveries. The complete system monitors outward transportation acid pipes between each gas gathering station and the internal and external corrosion of the acid gas gathering pipes.

Selecting the right solution

A corrosion monitoring system should be based on the specific corrosion and integrity management strategy of each individual case and often comprises both intrusive and non-intrusive methods. The goal is therefore to provide the best total monitoring solution for both intrusive and non-intrusive applications.

To this end, in addition to Emerson's non-intrusive FSM technology and upstream high-pressure technologies, Emerson has brought to market a new range of retractable-style (refinery), high temperature probes.

The intrusive range of probes are available with WirelessHART communications, making online monitoring available at an affordable price as well as enabling the linking in of other field applications related to pressure, temperature and vibrations. WirelessHART is widely accepted in the industry with integration between multiple monitoring and control applications now possible within the same network.

On the software side, the Roxar Fieldwatch software also offers advanced tools for data management and the reporting of corrosion monitoring data. Integration with Emerson's asset management software (AMS) or essential asset monitoring (EAM) software is also possible.

Other advantages of refinery probe monitoring are that the instrument reads both ER probes and LPR probes as well as being able to read probes from other suppliers; and the fact that the wireless instrument allows up to 20 m of cable between probe and instrument. This provides the necessary flexibility for finding the best location with respect to maintenance and line of sight for optimised wireless radio signal routing.

Corrosion is a continuous challenge for pipelines and other infrastructure in upstream, midstream and downstream operations today.

From intrusive probes and coupons through to the latest field signature method (FSM) developments and WirelessHART technology that is providing a catalyst for integration, operators are finally starting to get the choices they need.

References

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