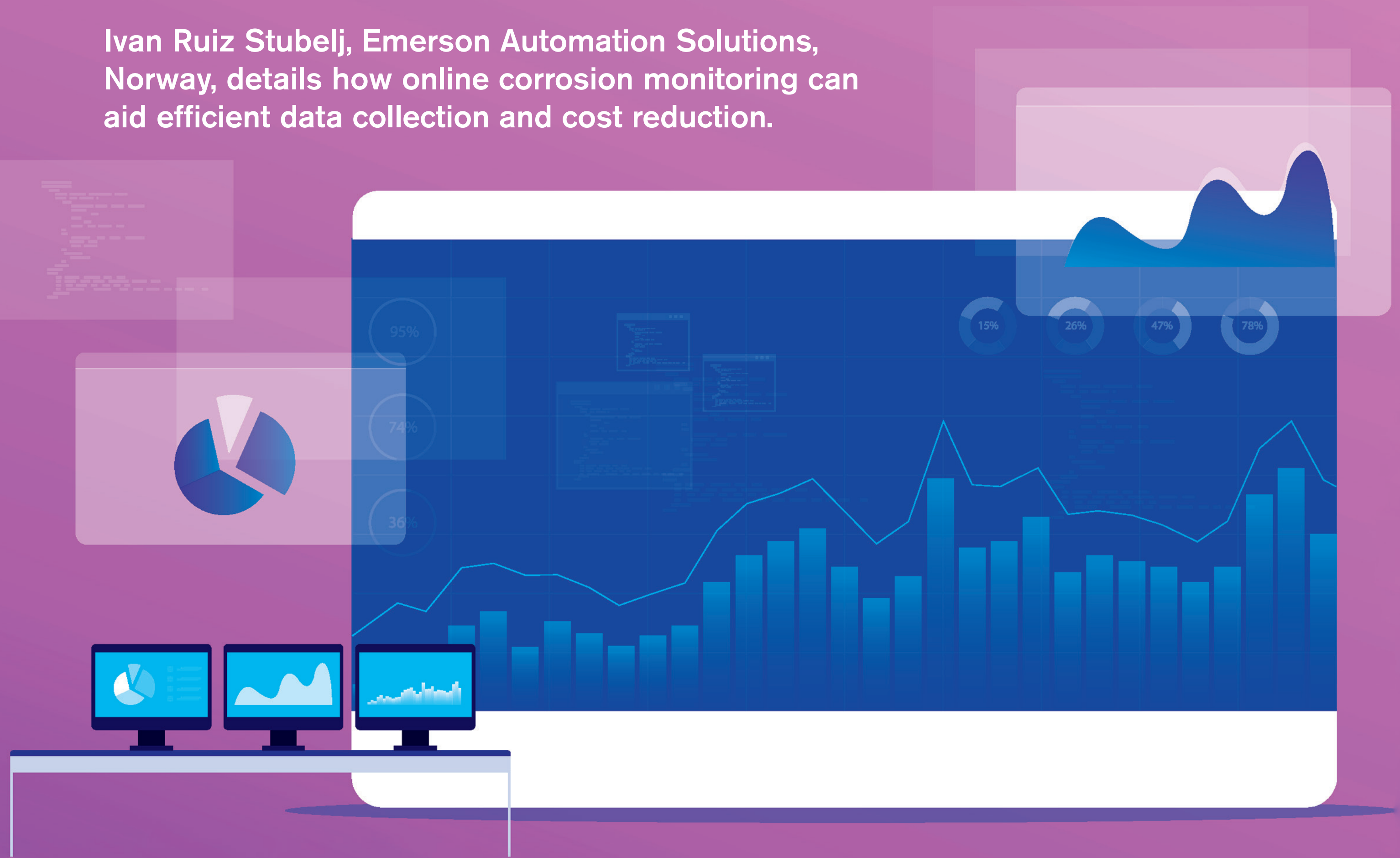
PUTTING IT ONLINE

Ivan Ruiz Stubelj, Emerson Automation Solutions, Norway, details how online corrosion monitoring can aid efficient data collection and cost reduction.



Pipelines today are vast and complex networks, delivering oil and gas from remote locations to gas processing facilities, refineries, petrochemical manufacturers and ultimately end-users. Today, there are over 2.175 million miles of pipeline in 120 countries worldwide, with corrosion being one of the biggest threats. The National Association of Corrosion Engineers (NACE) estimates that the cost of corrosion in pipelines is equal to US$7 billion/yr.

According to the current American Society of Mechanical Engineers B31.8S standard on managing system integrity of gas pipelines, the most critical category of threat to pipeline integrity is time-dependent threats, which include internal corrosion (the deterioration of the metallic structure of the pipe due to an electrochemical reaction between the pipe material and the environment inside the pipe), external corrosion, and stress corrosion cracking.

According to the Pipeline and Hazardous Materials Safety Administration, internal corrosion is also one of the main contributors to pipeline incidents, with the management of internal corrosion therefore critical to successfully operating a pipeline throughout its entire lifecycle.

Although internal corrosion is time-dependent, it is commonly assessed and managed through methods such as inline and direct assessment inspections, where measurement intervals can range from months to years and provide only isolated snapshots throughout the pipeline's lifecycle.

Relying only on these techniques can increase operating expenses and capital expenditures, leading to more cleaning pigging campaigns, non-critical inline inspections (ILI), and early pipeline replacements. Moreover, the lack of up-to-date corrosion information can cause excessive pipeline downtime and out-of-balance operations that reduce transportation capacity and lead to delivery obstacles.

This article will argue that in order for a pipeline integrity management system to be truly successful and cost-efficient, it will require online internal corrosion information not only from local and remote pipeline segments but also from processing stations, resulting in timely data-driven decisions.

Inspection and test tools

Many operators rely on ILI and direct assessment inspections to detect and quantify corrosion threats.

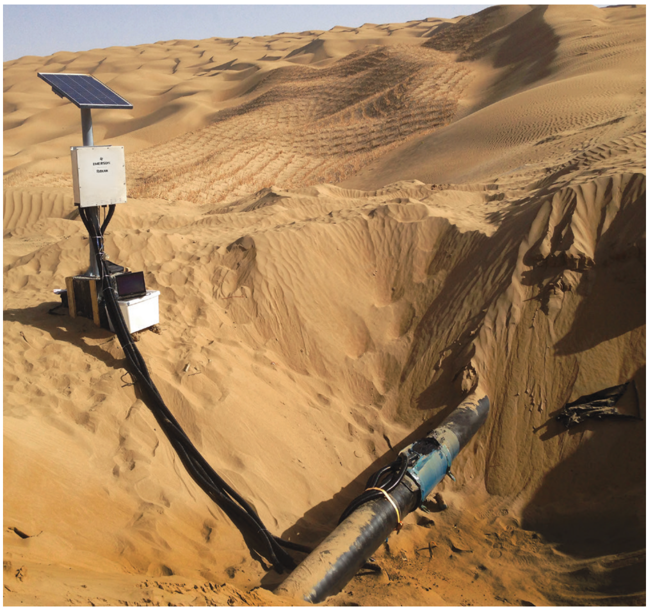


Figure 1. The field signature method (FSM) provides non-intrusive corrosion monitoring.

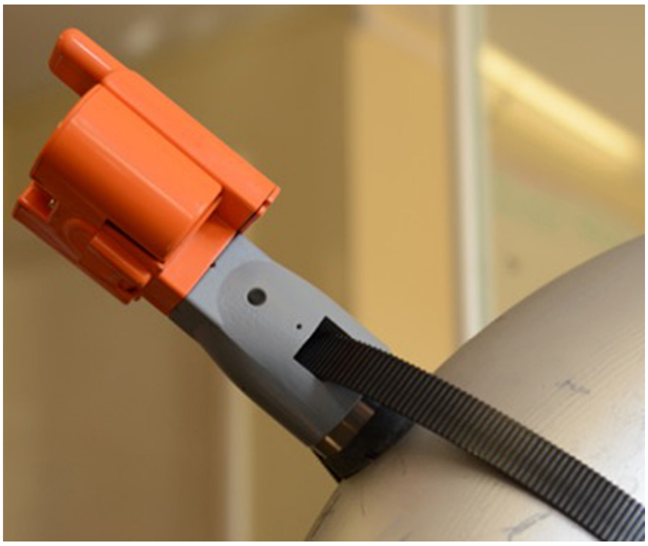


Figure 2. Wall thickness monitoring via UT measurements provides direct metal thickness measurements and detects defects over several decades.

ILI tools might include ultrasonic inspection or magnetic flux inspection, with an average running cost of US$33 000/mile. Direct assessment is often designed to complement ILI-based inspections through external corrosion direct assessment (ECDA), internal corrosion direct assessment (ICDA), and stress corrosion cracking direct assessment (SCCDA). These techniques have an average cost of US$85 000/mile.

Aside from the expense, both techniques come with their own challenges. In the case of ILI tools, there are access issues, non-piggable infrastructure, and the danger of pigs getting stuck – especially when large and remote areas must be monitored. With direct assessment, the discrete nature of the data points and the selection of the excavation location does not guarantee the data's repeatability.

Pipeline integrity management processes also require pipeline operators to periodically conduct integrity assessments through the pressure testing of certain pipelines and conditions. These types of operations can, on average, account for US$313 million for a 2000 ft segment. Therefore, performing this type of operation only when required is paramount to achieving cost efficiencies and maximum transportation capacity.

It is clear that all the activities mentioned above are fundamental pillars of a pipeline integrity management system. However, deciding when, how, and where to perform them depends on the best available data, to not only comply with the country's regulatory framework and HSE policies but also to support cost improvement initiatives. This is where online corrosion monitoring comes in.

Online monitoring

There are two broad types of technologies that continuously monitor corrosion: inline, intrusive sensors and non-intrusive technologies. Both these technologies generate at least one internal corrosion data point per day, which can generate a broad array of actionable information such as fluid corrosivity, wall thickness, pipe internal metal loss trend, and internal metal loss topography.

Moreover, with current communication and battery capabilities, sensors can be remotely located, with the total cost of ownership representing just a small fraction of one ILI run.

Inline sensors

Inline sensors and corrosion monitoring technologies include electrical resistance (ER) probes and electrochemical probes that provide high sensitivity and fast response times on changes in fluid corrosivity and corrosion rates. They are most commonly used for uniform corrosion measurement or the detection of changed fluid corrosivity. As an example, a 20 mm element probe can detect a corrosion rate of 5 mm/yr – defined by NACE International as moderate to severe – within hours, depending on measurement frequency. The high sensitivity makes probes valuable for the fast-track monitoring of process changes and for tuning processes, such as corrosion inhibitors.

ER probes are also commonly used for monitoring corrosion and are based on measuring changes in electrical resistance, as the thickness of the probe's measurement element decreases due to corrosion. However, sensitivity, reliability, and visualisation capabilities have significantly increased over the years. With today's instruments, ER probes have sensitivity in the nanometer range (1 nm = 1/1000 µm), offering responses to changes within hours or days.

With ER probes, corrosion is also detected, mitigated, and the effect of mitigation confirmed before it would be visible with any non-intrusive method.

There are also electrochemical methods, such as linear polarisation resistance (LPR) probes, that are mostly used for water systems. Such probes have an extensive history in generating direct corrosion rate measurements.

Non-intrusive technologies

There are two main forms of non-intrusive technologies: the field signature method (FSM) and ultrasonic (UT).

FSM technology is based on the potential drop technique and feeds current into a predefined buried or uncovered pipeline section, and – through a permanently installed sensing pin array – detects the produced electric field. Hydrocarbon transportation will generate internal general and/or localised metal loss, triggering a change in the monitored area's electric field. Afterwards, that change will be translated to not only average metal loss for the predetermined area, but also to a tomographic image that depicts the corrosion phenomena.

FSM will usually take between one and four measurements per day, detecting changes of approximately 0.1% of the monitored pipe or vessel wall thickness, and will require the placement of just three units on each 60 km of pipeline between compressor or pump stations. Through batteries, cellular, or other types of long-range communication, the referenced equipment will operate autonomously and inform digital metal loss values through an average of the area, or a heat map that can describe the corrosion phenomena morphology.

Wall thickness monitoring via UT measurements provides direct metal thickness measurements and detects defects over several decades. Installing UT sensors permanently on the pipe (clamped or stud-welded to any pipe section or asset) for regular measurements on the spot provides increased stability and sensitivity. Sensitivity for UT measurements is typically 10 µm for changes in wall thickness, and it is also possible from the form of the wave signal to determine surface conditions inside the pipe.

Wireless communications also make installation and data collection rapid and cost-effective, with the sensors able to be installed anywhere. The limited maintenance requirements and ease of installation also allow for a wide distribution of sensors for integrity management, and corrosion and process insights.

Data-driven decisions and cost savings

Online internal corrosion monitoring allows for timely decisions that will not only improve the operation's bottom line, but will also safely extend the pipeline segment's life.

Online monitoring is key to realising cost and operational benefits. Permanent corrosion monitoring locations can be deployed not only at uncovered positions in compressors, pump stations or processing facilities, but also in buried and remote locations within the pipeline. Each pipeline will also possess its own corrosion profile depending on several variables such as type of fluid, elevation angle, geometry, pH, H_2S content, water content, and temperature. Corrosion hotspots can be easily identified through computer models and previous integrity data, allowing a scalable rollout that, with the help of non-intrusive technology, will not impact transportation operations.

Once the pipeline operator deploys online corrosion monitoring sensors, information about the fluid corrosiveness, pipeline wall thickness loss, and localised corrosion proliferation can be easily obtained and shared throughout the organisation.

The availability and ease-of-use of such information can enable pipeline rehabilitation strategies that, as opposed to a full pipeline replacement, can reduce capital expenditures by 60% while keeping the same expected pipe lifecycle and reducing lengthy downtime periods.

Furthermore, internal corrosion information can reduce operating expenditure and allow the operator to efficiently run pig cleaning on demand, based on metal loss data. Smart pig run frequency can also be reduced, yet still comply with a country's rules and regulations. Direct assessment (also known as integrity dig) frequency can be reduced as a result of correlating multiple corrosion monitoring locations that use different, yet complementary technologies. The efficient use of all of the aforementioned integrity assessment methods can generate a cost reduction of approximately 30%.

Good timing

A successful pipeline digital strategy and effective predictive analytics are dependent on data capture techniques that provide diverse and continuous measurements. This can be achieved by incorporating intrusive and non-intrusive corrosion monitoring technologies, with captured data transferred to a pipeline integrity management system.

At a time when pipeline integrity management systems require more data to constantly monitor dynamic changes along infrastructure and leverage predictive analytics, and with a need to reduce both capital and operational expenditures, the rise in online corrosion monitoring techniques could not have come at a better time.

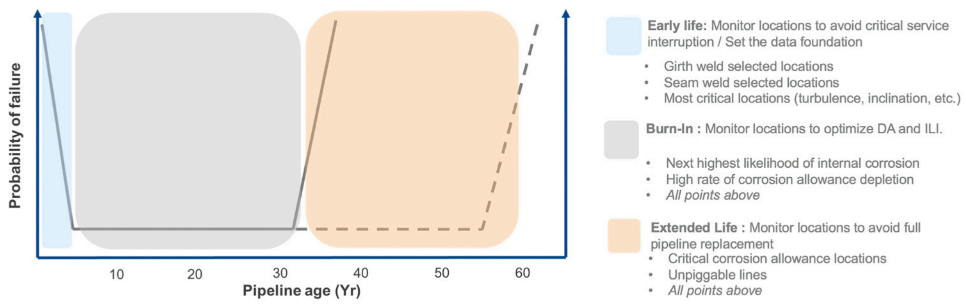


Figure 3. Pipeline lifecycle and online corrosion monitoring strategies.