Application Note

Internal Corrosion Monitoring in Oil and Gas Transportation Pipelines

The mode of transportation of petroleum products and crude oil through pipelines is ecofriendly and safe compared to other modes of transportation. Being a closed system, handling & transit losses are minimum hence pipeline is also considered as the most efficient mode of transportation. For effective transportation of petroleum products, a huge network of pipeline spread across the length and breadth of the country has been built over the years. According to a 2013 report[1,2], in the U.S. alone, there are a total of 192,396 miles of liquid pipelines and approximately 1,566,495 miles of gas pipelines including distribution mains, transmission pipelines and gathering lines.

Cross-country pipelines are the lifelines of energy security of every country. Nevertheless, there are inherent hazards associated with transportation of hydrocarbons through pipeline from leaks, spills, fires, etc. There is no denying the fact that pipelines laid out in public spaces and their aging pose safety risks. Moreover, about 33% of pipelines have been operating for more than 25 years and are still being operated at a maximum allowable operated pressure and achieving the yearly throughput targets.

In such aging pipeline infrastructure, causes of the failures are mainly: third party damage, corrosion (internal/external), construction/material defect, natural calamities/ground movement and operational errors. Out of these causes of failures it has been reported that corrosion has been responsible for 18 percent of the significant incidents (both onshore and offshore) in the 20-year period from 1988 through 2008. NACE currently estimates the total costs attributed to all types of corrosion to be $276 billion. Corrosion of onshore gas and liquid transmission pipelines represents $7 billion of this total[3].

Liquid and Gas Pipelines Internal Corrosion Issues

Internal corrosion in ‘dry’ gas pipelines is often overlooked because of an underestimation of the corrosion risk due to the perceived absence of water in the line. Under normal operating conditions, gas pipelines are under minimal corrosion risk; however, it is not possible to completely eliminate water from these pipelines. Water vapor is constantly condensing in the pipeline and can also enter through periodic upsets that cause water carry-over into the line. This water, coupled with corrosive factors such as CO_2, H_2S and O_2, can result in unexpected internal corrosion damage.

Most internal corrosion in crude oil transmission pipelines is caused by the settling of solid particles that can carry water to the pipe surface. Transmission tariffs are set to limit basic sediment and water (BS&W) to <1% (often 0.5%). The solid particles tend to be encapsulated by a layer of water that may concentrate water on the pipe wall surface and also provide sites for bacteria to thrive. This creates the potential for corrosion to occur if the flow conditions of the pipeline system allow for these solids to settle out. This type of corrosion is typically referred to as underdeposit or MIC corrosion and will often manifest as localized pitting. Moreover, pitting corrosion can proceed rapidly or lay dormant for extended periods of time, making this type of corrosion particularly difficult to predict.

In a long pipeline network such accumulation of water happens generally in low line areas where velocity of the bulk fluid is not (more than critical velocity) enough to carry this accumulated water to the downstream and that causes rapid corrosion. If corrosion is permitted to continue unabated, the integrity of a pipeline will eventually be compromised. In other words, the pipeline will fail. Depending on the flaw size, the pipeline material properties, and the pipeline pressure, failure refers to either a leak or a rupture.

Typically, rupture of a high-pressure natural gas pipeline results in such a sufficient release of stored energy (compressed gas) that the pipeline is blown out of the ground. A liquid (non-compressible) pipeline has less stored energy than a natural gas pipeline; therefore, a rupture does not immediately result in a major explosion. However, a major concern is the risk of product leakage into surface waters, thereby contaminating water supplies.

Internal Corrosion Monitoring Scheme for Pipelines

To mitigate internal corrosion risks, it is essential that structured guidelines are drawn for assessing the health of these assets. Generally, internal corrosion monitoring and detection is broken down into three techniques: intrusive, In-Line Inspection (ILI) and non-intrusive.

In-Line Inspection tools or Smart Pigs are intelligent sensing devices but they are periodic and don't provide corrosion measurement as it occurs with changes in operating conditions. The approach with ILI and non-intrusive measurement is like "find it and fix it". Also ILI is costly and not possible in non piggable sections of the lines. Out of the many non-intrusive devices the most common are ultrasonic monitors. These devices are quick, easy to use and inexpensive but have low sensitivity and still require spending thousands of dollars to dig up the pipeline each time testing is done.

Intrusive methods include electrical resistance probes and coupons. Coupons are the original form of intrusive corrosion monitoring. They are placed in pipelines in strategic locations and then are periodically removed and tested for corrosion. Corrosion coupons are an inexpensive and simple yet effective tool for providing a quantitative estimate of corrosion rates within a system that is in operation. The evaluation of corrosion coupons is a basic and widely used method of corrosion monitoring because they produce some of the most reliable physical corrosion evidence possible. They yield information on average material loss, corrosion rate, extent, distribution of localized corrosion, and the nature of the corrosion.

Similarly, online Electrical Resistance (ER) corrosion monitoring systems are also effective in monitoring for internal corrosion if placed in the proper location and oriented correctly. Unlike coupons, high sensitive ER systems can provide metal loss/corrosion rate measurements and episodes of higher corrosion rates in an online and continuous manner. Also it reduces huge man hours and hassles of field rounds, removal and insertion of the systems and associated costs. Corrosion results from online ER systems can identify trends that indicate acceptable or unacceptable corrosion protection, gains made by changes to a treatment program, or the need for improvements in protection or inspection programs or processes.

Correct placement of the coupons and online ER monitoring systems are critical to the accuracy of the evaluation. Coupons and ER probes must be placed as close as possible to the entry point of the electrolyte and in direct contact.

Metal Samples provides coupons in any size, shape and material with a large variety of (flush disc, strip or ladder strip) coupon holders to monitor corrosion in the pipeline. MS2500E/MS3500E Electrical Resistance probes (ER) are the most commonly used for on-line monitoring in pipeline systems. Metal Samples' **ultra-high resolution CorrVelox ER technology** is the latest addition to measure even minute changes in the corrosion rate. Also it provides the corrosion expertise to design custom probes that will suit specific applications and can assist engineering and installation teams to ensure a smooth implementation of the system. Once implemented, Metal Samples' support, for the purposes of data evaluation, validation and integration with the control system, helps users to realize the maximum value and benefit from the internal corrosion monitoring program.

References:
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3. Pipeline Corrosion FINAL REPORT, Submitted to U.S. Department of Transportation, Submitted by Michael Baker Jr., Inc; November 2008

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