Linear Anodes Target Aging Pipeline Coating Threats

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As pipeline operators implement integrity management programs, the effectiveness of existing cathodic protection systems comes under greater scrutiny. Pipeline owners battle aging systems with deteriorating coating systems that can have a significant negative impact on the effectiveness of the cathodic protection systems. With enough coating deterioration, the mandate to maintain effective cathodic protection sends owners and operators on a search for solutions.

External corrosion remains a significant threat for pipeline operators. Historically, pipeline owners have employed a two-tiered approach to mitigate corrosion risks. The first line of defense against corrosion has been a coating system that is intended to act as a barrier protecting the steel pipe from its environment. Cathodic protection is used to supplement the coating system by providing protective current to the holidays or defects within the coating system.

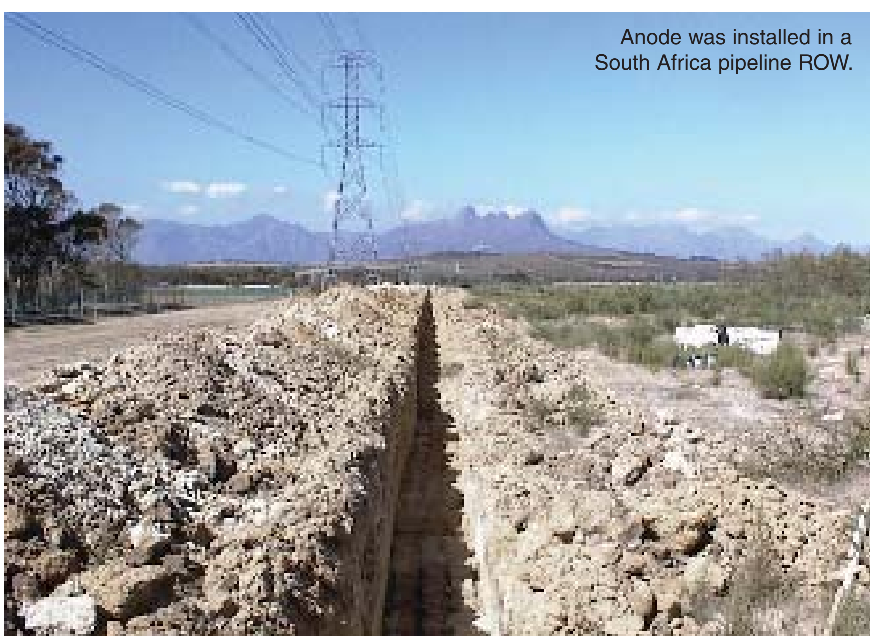
Recently adopted international standards for pipeline integrity provide procedures that collectively seek to address pipeline threats and specifically corrosion-related issues. Many practices in place for decades and the incorporation of advances in indirect survey technologies have ushered in approaches being adopted by pipeline operators worldwide. With this emphasis on integrity management, aging pipelines are receiving an unprecedented level of scrutiny.

What is the best strategy to remediate an aging pipeline and bring it into compliance with international standards? Initial options are to improve/upgrade the cathodic protection system or to recoat the pipeline. With extreme cases where significant corrosion has already occurred, the only option is to replace the pipeline. In the majority of cases, the burden of weighing the alternative of upgrading the cathodic protection system vs. incurring the cost of recoating is left with the pipeline operator. Ultimately, the goal of integrity management is to provide a structured approach to this type of pipeline operation decision and keep the focus on regular assessment and evaluation of the pipeline's critical areas.

Installation of MATCOR Linear SPL™-Anode at a Houston site

Coating Systems

Coating systems have been used on buried pipelines during the last hundred years and the technology remains the subject of great research and innovation. Manufacturers are continually searching for better coatings to meet the varied needs of industry. At first, the coatings were simple mixtures of crude pitches and solvents. These early bitumastic/asphaltic systems evolved into engineered coal tar enamel coating systems which were prevalent into the 1960s. The introduction of fusion bonded epoxies (FBE) in the 1970s quickly captured much of the pipeline market, although polyethylene, polypropylene and coal tar enamels are still used as well.



Anode was installed in a South Africa pipeline ROW.

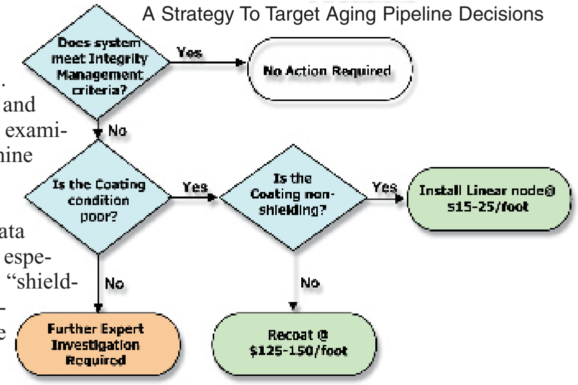
When evaluating aging pipelines, coating condition is one of the critical issues that must be addressed. The coating provides the primary defense against corrosion but as the coating system ages and deteriorates, the risks of corrosion increase exponentially. One challenge that must be addressed by pipeline owners is to properly identify the type and vintage of the coatings along a given pipeline.

In many scenarios, different sections of pipeline may have different coating systems, depending on the age of the pipeline and the standards in place at the time a particular section of pipe was installed, repaired or replaced. As part of the integrity management process, during the pre-assessment phase, pipeline attributes are defined for each segment through a process that includes documenting the type of coating used during the construction along with the repair methods and history of the line.

One critical consideration when evaluating aging pipeline coating systems is to identify whether the coating system fails in a shielding or non-shielding mode. Coating systems that fail in a non-shielding mode do not inhibit the flow of current to the pipe surface, making upgrading of the cathodic protection system a viable alternative to recoating when considering how to remediate these lines. Other coating systems, principally tape coating systems, can fail in a manner that shields cathodic protection current and thus make recoating the only viable option.

Modern, over-the-line survey technologies are effective in evaluating coating quality and finding coating holidays for "non-shielding" coatings. Technologies such as pipeline current mapping (PCM) which utilize a carrier signal transmitted along the pipeline with a receiver measuring the line attenuation along the pipeline length accurately pinpoint areas of significant coating degradation even under concrete or asphalt. The information gathered using PCM in conjunction with pipe to soil close interval surveys (CIS) and direct current voltage gradient (DCVG) testing form the basis for identifying critical risk areas along aging pipelines.

For pipelines with "shielding" coatings, the over-the-line surveys and indirect assessment technologies have been proven to be less than effective. For these pipelines, soil surveys and an increased frequency of direct examination (digs) are used to determine coating condition. Inline inspection technologies using smart pigs also provide valuable data regarding coating quality and are especially useful for pipelines with "shielding" coating systems where indirect assessment technologies are not very effective.



A Strategy To Target Aging Pipeline Decisions

Cathodic Protection

Pipeline coating systems are typically augmented by the application of cathodic protection. With a well-coated pipeline, cathodic protection can be economically applied to protect coating holidays and defects by the placement of discrete anode beds capable of distributing current over long distances.

In many cases, ground beds can be located several kilometers apart and still provide sufficient current distribution to protect the entire pipeline. With some of today's high technology factory-applied coatings, the coating efficiencies are exceptionally high and the groundbed output requirements are very low. These discrete ground bed systems can either be deep anode ground beds or shallow ground beds located some distance off the pipeline.

Several issues must be considered when designing a cathodic protection system. These include coating quality, soil resistivity, available locations for electrical power, ground bed right-of-way issues, accessibility for maintenance, and AC and DC stray current interference.

What is critical for aging pipelines is the regular evaluation of the effectiveness of the CP system. Frequently, as pipelines age and the coating quality begins to deteriorate, the CP systems are unable to provide sufficient, properly distributed current to meet established cathodic protection criteria. Simply ramping up the output of the existing system or adding additional ground beds does not always sufficiently address the problem.

Aging Pipeline Systems

Aging pipeline systems with deteriorating coating systems suffer from poor current distribution and are characterized by areas of low potentials and exceedingly high levels of applied current density. The challenge with these pipeline systems is controlling current distribution to achieve the prescribed polarization levels consistent with international standards for adequate cathodic protection.

The typical response to this problem is to increase the overall output of the deep well system. This generally does not alleviate the problems of not meeting the OFF-potential criteria and leads to over-polarizing the piping (OFF-potentials greater than -1.2 Volts.) This can result in coating disbondment, further exacerbating the problem. The higher output current increases the ground bed's consumption rate reducing operating life while raising operating costs appreciably. All this occurs without achieving the required levels of polarization to meet cathodic protection criteria.

The next step that is taken to fix the cathodic protection current distribution problem is to add additional ground beds to reduce the distance between point sources. This too, may prove to be ineffective as the new ground bed provides only limited additional benefit.

Factoring In Cost

Unfortunately, the problem cannot be economically resolved by the addition of an ever increasing number of ground beds applying greater amounts of additional current. The pipeline operator is then faced with the original, limited number of options: recoat the pipeline or install a linear anode cathodic protection system.

Recoating/replacing is the only viable alternative for pipeline systems utilizing shielding type coatings such as tape wrap systems. Recoating costs typically run $125-150/foot in open right-of-way areas and can be significantly more expensive in congested urban locations (these are typical numbers applicable to the U.S. and can vary significantly.) Recoating, when properly performed, can restore the pipeline coating system to an as-new condition, greatly extending the service life of the recoated section. The critical issue is to ensure that the recoating is executed by an experienced coatings contractor with rigorous quality controls in place.

Linear Anode Alternative

An economically attractive alternative to recoat is to utilize a linear anode configuration in lieu of discrete systems. This option is only viable when the coating system is non-shielding — this would include asphaltic and epoxy-type coating systems. The application of a linear anode system typically costs between $15-25/foot in open right-of-way (again these are general price guidelines and can vary significantly.) These systems eliminate the current distribution problems experienced by point anode systems; they are, in effect, an infinite series of point anodes which provide an optimum current distribution.

It is important to work with a corrosion engineering firm with proven experience in product selection, versatility, and consistent adherence to standards. In addition to confirming that the pipeline coating system is appropriate for the application of linear anodes, the linear anode system design must take into consideration the critical issue of voltage drop and its effect on current attenuation.

Voltage drop can have a significant impact on DC power distribution to the linear anode system. Ideally, rectifiers would be located no further than a half mile to a mile apart; however, practical considerations including availability of AC power, right-of-way issues and other factors can force this to be extended further, complicating the system design and affecting the installed cost.

While the design can be complicated by voltage drop considerations, one benefit of a linear anode system is that the power consumption is relatively low. Ground bed resistance, as determined by Dwight's Equation, is significantly affected by anode length and this results in very low groundbed resistance values for linear anode systems relative to conventional ground beds.

This makes the linear anode system much more suitable for low wattage power sources such as solar arrays and thermo-electric generators (TEGs) than conventional ground beds whose wattage could be two or more times that of a linear anode system to achieve the same current discharge. Industry-leading engineering firms should walk through these factors and considerations relative to a pipeline operator's individual circumstance.

Aging pipeline systems with deteriorating coating systems present a difficult challenge and time can often exacerbate a pre-existing condition. The more the coating deteriorates, the more difficult it is to distribute current farther away from the ground bed. Ultimately, pipeline operators should think carefully and consult industry experts to help them face the choice of recoating the pipeline or installing a linear anode system. The challenge can be an opportunity to not only solve a short-term threat but also institute a method for proactive prevention down the road. ***P&GJ***

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