Improvements to the External Corrosion Direct Assessment Process—Part 1

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The U.S. Department of Transportation (DOT) Pipeline & Hazardous Materials Safety Administration (PHMSA) sponsored a research project for improvements to the external corrosion direct assessment (ECDA) process. Part 1 of this article covers ECDA of cased pipe. Part 2 (April 2011 MP*) will cover severity ranking and potential measurements in paved areas.*

For cased pipe, improvements to the external corrosion direct assessment (ECDA) process include identification of applicable new technologies, development of techniques for the application of existing technologies, and creation of a threat matrix for cased pipes. The research led to a recommended ECDA methodology for cased pipes.

The purpose of the cased pipe study was to determine the applicability of existing and emerging technologies to assess cased pipes for external corrosion using ECDA. This included examination of existing ECDA processes, best practices of pipeline operators, and emerging technologies. The project findings are significant for gas transmission pipeline operators in the United States because the integrity of all pipe in high-consequence areas (HCAs) must be assessed by December 17, 2012, including those segments of pipe in casings. There is an industry need for a methodology to assess cased pipe where in-line inspection and pressure testing are neither possible nor practical. There are currently a number of emerging technologies that could be used on cased pipe, such as:

- Electromagnetic wave
- Pulsed eddy current
- Conformable array
- Magnetometer electrochemical impedance spectroscopy
- Robotic cameras and sensors

Although these technologies are promising, they will likely take years to develop.

Both past and current research and testing have demonstrated that cathodic protection (CP) current can reach cased pipes when an electrolyte is present in the annulus between the pipe and casing, even if the casing is electrically shorted to the pipe.[1] Consequently, standard CP and protective coating survey techniques should provide valuable information regarding the condition of the protective

coating and the level of CP on pipe within a casing, recognizing the limitations that may be created by shorted conditions, coated casings, and no filling, intermittent filling, or partial filling of the annulus with groundwater.

A matrix was developed to identify external corrosion threats for pipes in casings. The threat matrix can be used to prioritize cased pipe for assessment. It incorporates construction, operations, and maintenance parameters such as:

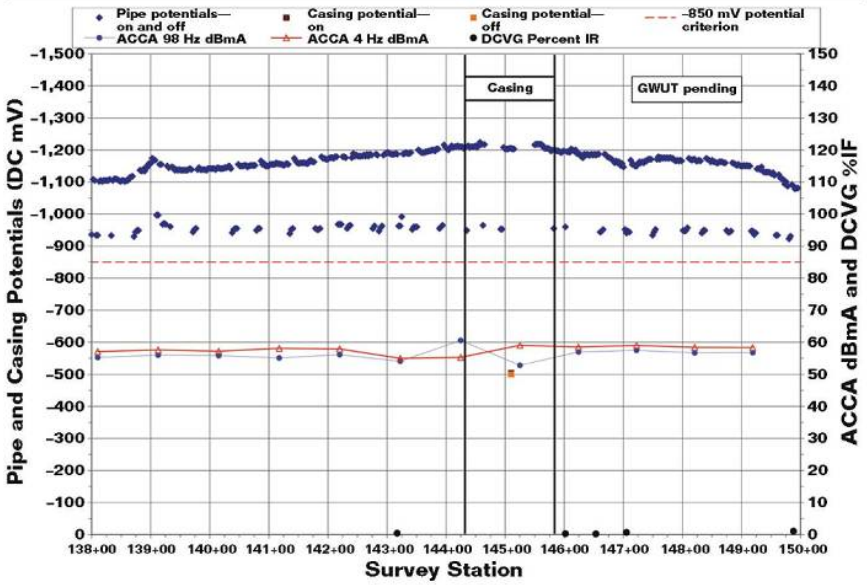
- Electrical isolation
- CP
- Survey indications
- Groundwater level and fluctuations
- Annulus atmosphere
- Age
- Pipe coating
- Casing coating
- High temperature

The developed cased-pipe ECDA methodology follows the general steps in the process delineated in NACE SP0502-2008.[2]

Preassessment

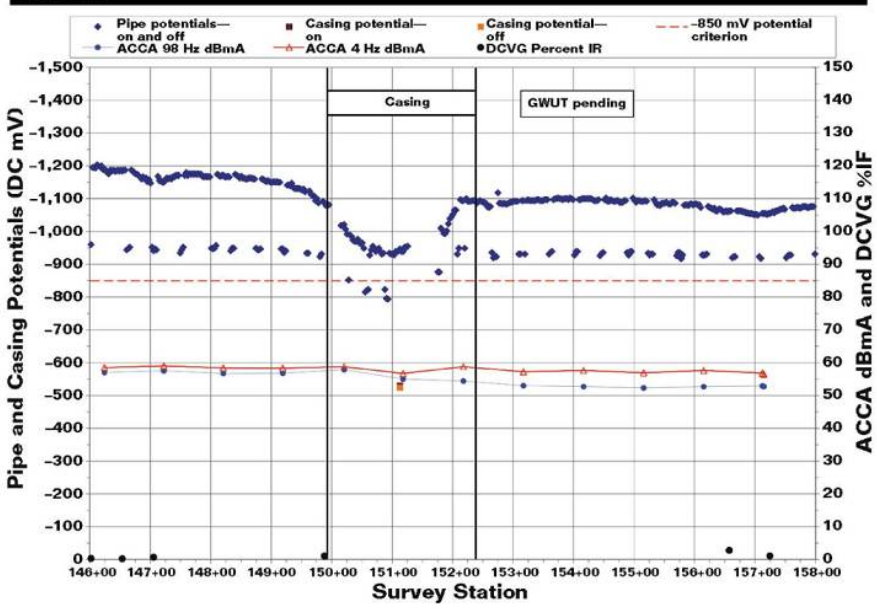
The preassessment step requires compiling and analyzing construction, operation, and maintenance information for the cased pipe under study. Annual CP survey data, including pipe-to-soil (P/S) and casing-to-soil potential measurements, and close interval survey (CIS) data should be reviewed. Possible external corrosion mechanisms should be identified and ECDA regions defined. A feasibility analysis needs to be performed to include a critical determination of conditions that could prevent or alter electrical measurements on the pipe within the casing, such as casings that are electrically shorted to the pipe, coated casings, and lack of electrolyte within the casing. The ECDA indirect inspection (IDI) tools must then be selected to accommodate pipe and casing conditions.

FIGURE 1



Survey data from a pipe electrically isolated from the casing.

FIGURE 2



Survey data of an electrically isolated cased crossing.

Indirect Inspection

The IDI tools for cased-pipe ECDA are the same as those used for direct buried pipe. A minimum of two tools are required. At least one tool should address protective coating condition and defects, and the other should evaluate CP levels and detect CP indications with CIS. IDI tools used for cased pipe are primarily CIS, direct current voltage gradient (DCVG), alternating current (AC) attenuation (ACCA), and AC voltage gradient (ACVG). The methodology requires that IDI be performed over the entire length of cased pipe plus 300 ft (91 m) beyond both ends.

For this project, data were collected and analyzed for more than 200 cased

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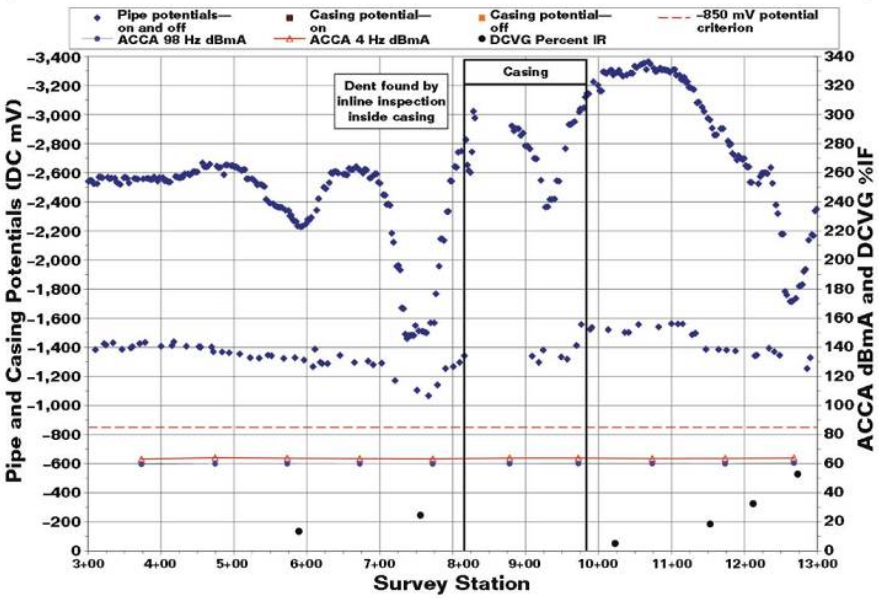
FIGURE 3



Survey data from a cased pipe where the electrical isolation of the casing is unknown.

pipes and adjacent, uncased pipe for six transmission and distribution system operators. Figures 1 through 3 illustrate the data collected from three of these surveys.

Figure 1 contains data from a pipe that is electrically isolated from the casing as demonstrated by a 700-mV difference in pipe and casing potentials, and by the identical on and instant-off current potentials on the casing. There were no DCVG indications within the casing but the ACCA survey results indicated a change in signal strength within the casing. Both on and instant-off CIS data suggest CP levels that satisfy the criteria in NACE SP0169-2008.[3] There were no changes in potential at the ends of the casing and valid measurements were collected above the casing at grade. (Data were not collected over the paved areas.) The ACCA indication corresponds to an area where CIS data could not be collected.

Figure 2 shows data from an electrically isolated cased crossing. Note the ACCA indication dips in both on and instant-off potential measurements as the casing is approached, and continues as data are collected over the casing. There was a DCVG indication at the upstream end of the casing. All IDI inspection data are normal with no apparent abnormalities associated with data collection over the cased pipe.

Figure 3 illustrates data from a cased pipe where the electrical isolation of the casing is unknown (no vents or test leads connected to the casing). CIS and DCVG data correlate in demonstrating coating defects as the cased pipe is approached. Another coating defect was also identified inside the casing, which correlated with the location of a dent found by ILI.

The aforementioned are examples only. The data from the 200 cased pipes that were tested clearly indicate that IDI survey techniques can be used for ECDA of pipelines within casings, subject to certain limitations. Further, the research data were used to develop the IDI severity ranking (Table 1).

A method for direct examination action prioritization of IDI indications was then developed (Table 2) from the data in Table 1.

Direct Examination

Referencing Table 2, all cased pipes with an action priority of "immediate" are to be examined within the period of time commensurate with the indicated conditions. Cased-pipe locations prioritized as "schedule" are to be examined before the next integrity assessment. Cased-pipe locations with action priority "monitor" are to be monitored at appropriate time intervals until the next integrity assessment is performed. No action is necessary for those locations indicated as such. Direct examination techniques include visual inspection, ILI, pressure test, guided wave ultrasonic testing (GWUT), electromagnetic wave, and other acceptable techniques either individually or in combinations.

Post Assessment

Evaluations of the direct examination results of cased pipes with action priorities of "immediate" and "schedule" determine the need to perform additional direct examinations on those cased-pipe segments with a priority of "monitor." Reassessment intervals are then set independently of adjacent, uncased, buried pipe. A very rigorous evaluation of the effectiveness of the ECDA methodology for the cased-pipe segments studied should then be performed.

Conclusions

The cased-pipe portion of the project concluded:

- ECDA can be used to evaluate the integrity of cased pipe in accordance with a recommended methodology.
- The methodology makes use of ECDA IDI survey techniques currently being used for uncased, buried pipe, as part of the process for identifying and ranking direct examination priorities and selecting the most effective assessment tools.
- Direct examination techniques include visual inspection, ILI, pressure test, GWUT, and electromagnetic wave either individually or in combinations.

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TABLE 1

IDI severity ranking

Indirect Inspection Survey Tools	Severity Classifications			
	None	Minor	Moderate	Severe
AC attenuation survey	Uniform attenuation profile with no significant changes inside or near casing	Small change in attenuation profile over short length of pipe inside or near casing	Moderate change in attenuation profile over short length of pipe inside or near casing	Large change in attenuation profile over short length of pipe inside or near casing
DC or AC voltage gradient survey	No indications on adjacent buried pipe –and– no indications on cased pipe	Few indications on adjacent buried pipe –but– no indications on cased pipe	Several indications on adjacent buried pipe –but– no indications on cased pipe	Numerous indications on adjacent buried pipe –or– indications on cased pipe
Close interval potential suvey	Uniform potential profile with no significant depressions –and– all potentials more negative than –850 mV	Minor potential depressions –but– all potentials more negative than –850 mV	Moderate potential depressions –but– all potentials more negative than –850 mV	Large potential depressions –or– any potentials less negative than –850 mV

TABLE 2

Action priorities for IDI indications

Action Prioritization for Cased Pipe Segments Based on Indirect Inspection Survey Severity Classifications			CP Severity Classifications Based on Close Interval Potential Survey Results			
			No Indications	Minor Indications	Moderate Indications	Severe Indications
Coating condition severity classifications	Based on AC current attenuation survey results	No indications	No action	Monitor	Schedule	Immediate
		Minor indications	Monitor	Monitor	Schedule	Immediate
		Moderate indications	Monitor	Schedule	Schedule	Immediate
		Severe indications	Schedule	Schedule	Immediate	Immediate
	Based on DC or AC voltage gradient survey results	No indications	No action	Monitor	Schedule	Immediate
		Minor indications	Monitor	Monitor	Schedule	Immediate
		Moderate indications	Monitor	Schedule	Schedule	Immediate
		Severe indications	Schedule	Schedule	Immediate	Immediate

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- It is possible for cased pipe with a water-filled annulus to be categorized as "no action" required or "monitor."
- There are limitations to the use of ECDA as a tool for integrity management of cased pipes that need to be recognized and understood.

Acknowledgments

We would like to acknowledge the PHMSA funding and support for this work, and the contribution of time and effort from our team members—El Paso, ExxonMobil, Southern Union, and the Texas Gas Association.

References

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