Where To Dig Is The Key Question In Integrity Rule Compliance

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While pipeline integrity has always been a critical concern for the oil and gas industry, recent federal legislation mandates that all pipeline companies adopt a rigorous program to ensure that they take proactive steps toward preventing failures.

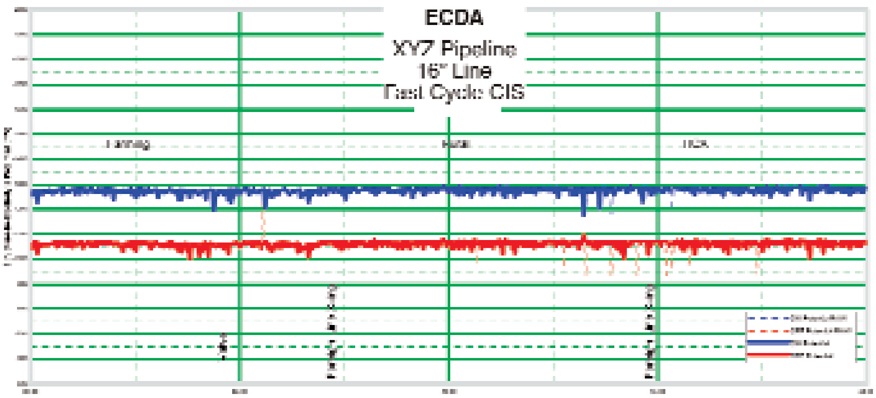
One of the tools available as part of the Pipeline Integrity Management regulations is ECDA (External Corrosion Direct Assessment). ECDA is an evolving process of using indirect examination techniques to pinpoint areas of concerns along the pipeline. As part of the process, the pipeline company is required to validate these indirect examination results through a series of direct examinations, or digs. These digs can be very expensive. Analyzing the indirect examination data properly enables the pipeline to minimize the number of digs required to validate the ECDA results and satisfy the regulatory requirements.

As the two examples in this article will demonstrate, the pre-assessment information combined with the indirect survey data — when properly evaluated -will define the quantity and location of digs. The challenges facing the pipeline operator in determining where to dig consist of the following:

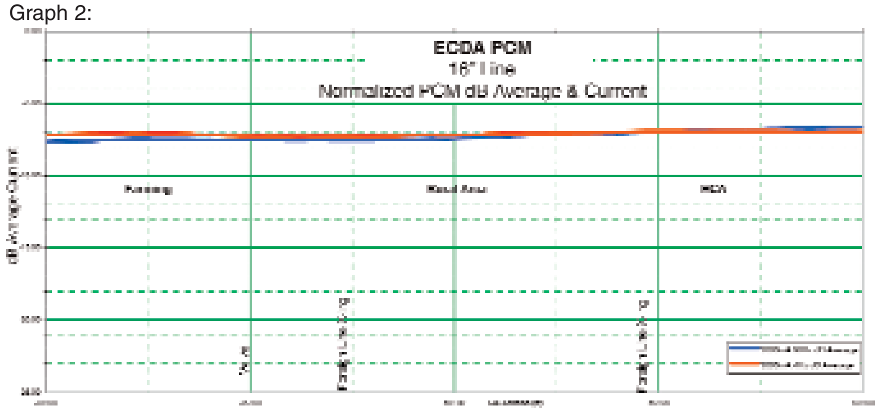
- Areas of concern (anomalies that are out of code — immediate action required). These include isolated anomalies (random occurring) and multiple anomalies (grouped together on a joint or joints of pipe).
- Areas of interest (larger coating holidays with no corrosion).
- Areas of no concern (smaller coating holidays with no corrosion).

Identification, classification and prioritization of those indications for direct examination have been one of the major challenges using indirect exams or aboveground surveys combined with pre-assessment, risk assessment and threat assessment information.

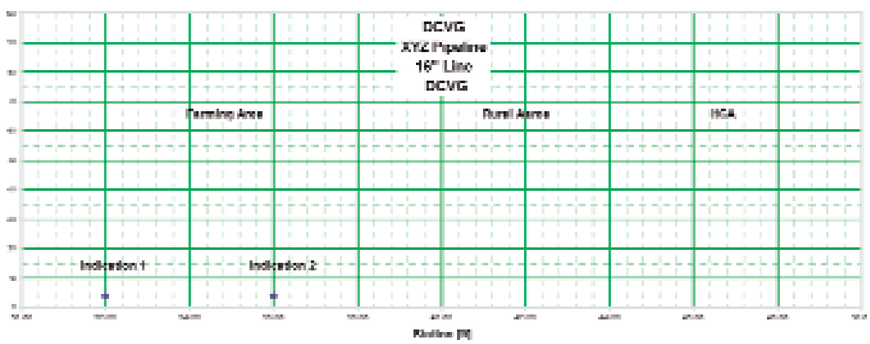
Graph 1:



Graph 2:



DCVG. The next survey method selected was DCVG because of the open R/W and the possibility of small isolated that may exist. Two indications, approximately 4% IR were found in the farming area.



Setting Priorities

Once the pre-assessment and indirect examinations have been completed, the goal is to prioritize/define coating holidays and defects. Some factors that must be considered are:

1. Coating holiday size and number. These could be multiple or isolated.
2. Active corrosion or on-going.
3. Shielded conditions. These can be disbonded high-dielectric coating materials, rocky terrain, rock ledges, or rock backfill.
4. Stray currents, including dynamic and static.
5. Other metallic structures such as foreign line crossings.
6. Parallel pipelines.
7. High voltage, including alternating or direct currents.
8. Shorted casings.
9. River and water crossings.
10. Roads and railroads.
11. Physical characteristics of each ECDA region under year-round conditions.

Threat identification of all potential

threats to a pipeline segment must be considered as in ASME B31.8S. The following three main classifications of potential threats must be considered:

1. Time dependent treats (external, internal and SCC).
2. Static or resident threats (materials and construction).
3. Time-independent threats (third party or outside forces).

Once the particular threat(s) of pipeline regions have been determined through the use of risk assessment techniques and identified, then a baseline assessment can begin which will include the type of tools and surveys that can be used. The actions to address the various threat(s) will determine the methods to assess the integrity of the region. More than one method or tools may be required to address all the threats.

Scenario No. 1

This will focus on external corrosion (time dependent) and possible damage through outside forces where farming activities exists on the rural sections of this line. Pre-assessment information for this particular line:

1. 16-inch diameter line with .250 WT and .312 WT at road crossings.
2. Coal tar enamel.
3. Operating data — temperature 110ºF, no stress levels, excavations indicate coating is in good condition, monitoring conducted annually.
4. Approximately one mile in length.
5. Good cathodic protection since first year of operations.
6. One HCA.
7. Farming areas with deep tiling.
8. No history of corrosion, material, construction or third-party damage.
9. Soils and environmental characteristics were relatively benign — soil type is sandy loam, resistivity is 15,000, drainage is good, topography is flat, land use is for farming, and pipe depth is 2.5-feet.

Since there was no history of external corrosion, material defects or construction problems, ECDA was selected to determine the potential threats of possible coating damage at the HCA sites and a deep tilled farming area. Close interval survey was conducted to determine the overall performance of the cathodic protection system and DCVG was selected to determine if any coating defects existed.

Pipeline Current Mapper (PCM) was also used to determine/locate the centerline of the pipeline, assess macro type anomaly indications and geo-reference the aboveground features. In addition, a soil resistivity survey was conducted at all areas of interest to determine if corrosivity of the soil was a factor.

The surveys were conducted using intervals spaced closely enough to permit a detailed assessment. In addition, they were conducted concurrently to minimize issues with geo-referencing in order to identify potential excavation sites. The

Table 1:

Inspection Tools	Classification Severe Indications	Classification Moderate Indications	Classification Minor Indications
CIS	Two or more of the following must exist: ■ OFF Potential less than — 850 mV ■ ON Potential less than — 850 mV ■ Reduced Potentials shifted in a positive direction	Two or more of the following must exist: ■ OFF Potential less than — 850 mV ■ ON Potentials greater than — 850 mV ■ Reduced ON Potentials sifted in a positive direction	Any of the following can exist: ■ OFF Potential @ or near -850 mV ■ ON Potential above -850 mV ■ Single spikes ■ Saw tooth patterns in both ON & OFF ■ Step Potential
PCM	Greater than 20% change in 100 feet	Between 10 and 20% change in 100 feet	Less than 10% Change in 100 feet
DCVG ACVG	36% to 100% IR Anodic/Anodic > 90 dB	16% to 35% IR Cathodic/Anodic 50 to 89 db	1% to 35% IR Cathodic/Neutral Cathodic/Cathodic <50 dB

Table 2:

Inspection Tools	Classification Severe Indications	Classification Moderate Indications	Classification Minor Indications
CIS	One or more of the following must exist: ■ Less than 700 mV OFF ■ 200 mV depression over baseline ■ Convergence ON/OFF potentials.	One or more of the following must exist: ■ Less than 750 mV OFF ■ 200 mV OFF depression over baseline.	Any of the following can exist: ■ Between 800 to 850 mV OFF ■ 200 mV drop ON
PCM	Greater than 20% change in 100 feet	Not applicable Between 10 and 20% change in 100 feet	Less than 10% Change in 100 feet
DCVG/ACVG	6 or more indications per 100 feet	4 to 5 Indications per 100 feet	1 to 3 Indications per 100 feet

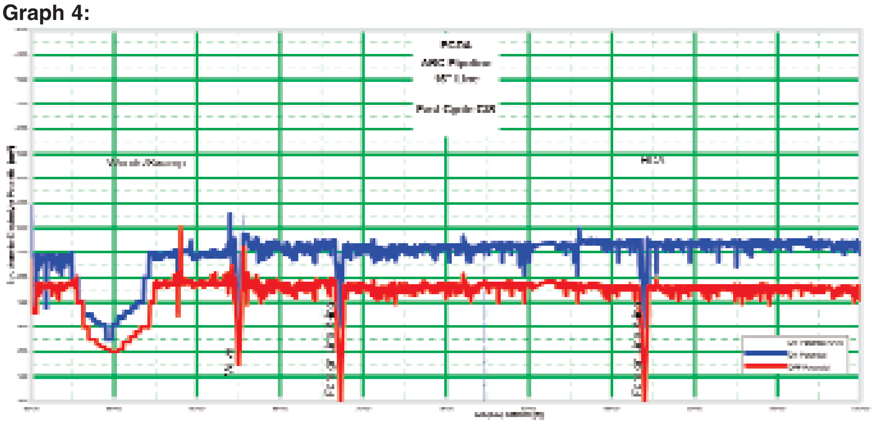
Beg Sta No	End Sta No	CIS	PCM	DCVG	Table 1P/F	Table 2 P/F
32+00	32+00	No Change	No Change	Single 4% IR	Passed	Passed
36+00	36+00	No Change	No Change	Single 4% IR	Passed	Passed

Table 3: Guidelines For Determining Digs

Immediate Action	Scheduled Action	Monitoring	No Indications In Segment
Perform digs on all severe indications that are prioritized as immediate.	Perform one excavation on the most severe moderate indication the region. If excavation fails remaining strength for corroded pipe or is more severe than immediate indication, then one more dig is required.	Perform one indication if no immediate or scheduled are required	Perform @ least one dig in the region as the most likely to be a threat for corrosion or damage.

First time ECDA requires two digs per region. Otherwise, one excavation is required for the entire region.

Graph 4:



results were aligned and compared using data integration.

Based on the preliminary information as shown in Graph 1, the pipe-to-soil potentials both ON and OFF are well above the criteria for cathodic protection. This affirms the original assumption from the pre-assessment data that the line has been well maintained in accordance with good corrosion engineering standards. It also affirms that the coating appears to be in good condition which is indicated with the results of the PCM survey as shown in Graph 2, indicating good current attenuation or no current loss.

How Many Digs?

In order to determine the number of digs, these requirements must be considered in total. The required steps for direct examinations include the following:

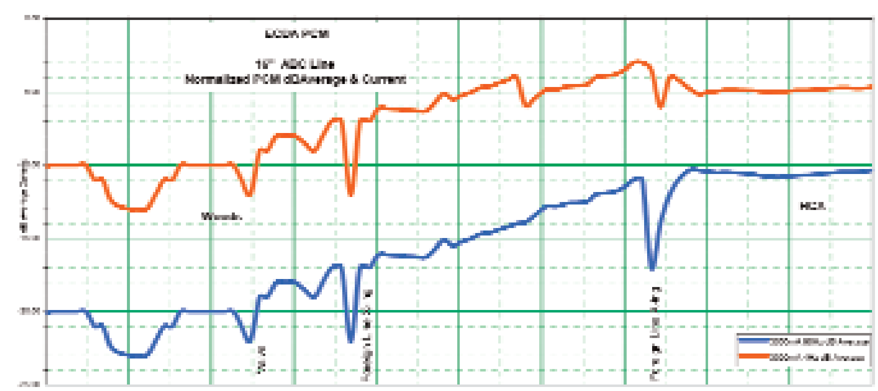
1. Prioritization of indications into categories for bell hole examination (See Tables 1 and 2 for indication categories), including immediate (classified as severe by more than one indirect exam or individual severe indications of prior corrosion); scheduled (classified as severe indications that were not placed in an immediate category or moderate indications in regions of significant prior corrosion); and monitored (all remaining indications not classified as immediate or scheduled).
2. Bell hole and direct data examination at the areas likely to experience corrosion or third-party damage.
3. Coating and corrosion damage measurements (assess coating condition and corrosion product).
4. Determine remaining strength of pipe using such methods as RSTRENG, B31G and modified criterion or other approved assessment.
5. Root cause analysis or condition assessment, including a. inadequate CP; b. coating failure; c. improper selection of materials (shielding or disbondment).
6. Mitigation steps such as recoat damaged coating, repair with composite or steel sleeve, install additional cathodic protection such as with long line linear anodes, or replace pipe.
7. Evaluation of results to determine criteria for indications. Indirect examination results categorized as immediate, scheduled and monitored. Corrosion and other defects physically found. Root cause analysis.
8. Reclassification of remaining indications and reprioritization based on direct exam results. a.) Adjust criteria up or down based on results found. b.) If corrosion is found to be worse than classified, complete readjustment or resurvey will be required. c.) If an indication was less than classified, move down one category, or — if no longer a threat — remove from consideration.

Prioritization

Two examples of prioritization tables are nearby. Table 1 is designed for >95% effective coating system; whereas Table 2 is designed for aged pipeline system with many coating indications and flaws. Tables can be set up in accordance to geographic areas, type coatings and factors. However, they must comply with NACE RPs, B318.S criteria and the Code of Federal Regulations.

Since the 16-inch XYZ pipeline exhibited good coating conditions, good ON/OFF pipe-to-soil potentials, excellent current attenuation, two minor DCVG indications, benign soil conditions, and no history of corrosion or defects (see comparison table), it can be determined from Table 3 that one dig is required for that region.

Graph 5:



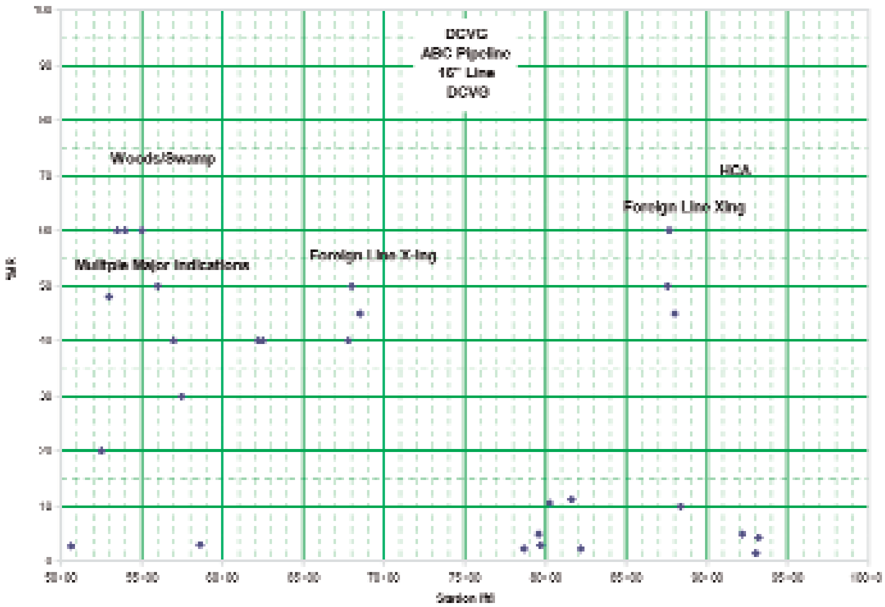
Since this was the first time an ECDA was conducted on XYZ pipeline in this region, the two 4% DCVG indications were selected for direct examinations because of the threat of damage to the pipeline in the deep-tilled farm area. All other aboveground surveys indicated that there were no problems. This remaining direct examination step must be completed in order to complete the process before moving to post-assessment.

Scenario No. 2

This will focus on external corrosion (time-dependent) and possible third-party damage from construction activities that may have occurred on this line. Pre-assessment information for this particular line:

1. 16-inch diameter line with .250 WT and .312 WT at road crossings.
2. Asphalt enamel wrap.
3. Operating data — temperature of 110°F, stress levels — unknown, recent excavations indicated coating in poor condition (monitoring was intermittent over the years).
4. Region approximately one mile in length.
5. Cathodic protection since first year of operations.
6. One HCA area.
7. History of corrosion, material, construction or third-party damage.
8. Soils and environmental characteristics were relatively benign — clay soil type, high resistivity, poor drainage, hilly topography, undeveloped land use, pipe depth varies from one foot to 2.5 feet.

Since there was a history of external corrosion, material defects and construction problems, an ECDA region was selected to determine the potential threats of possible coating damage, interference and an HCA site. Close interval survey was conducted to determine the overall performance of the cathodic protection system and DCVG was selected to determine if any coating defects existed. Pipeline Current Mapper (PCM) was also used to determine/locate the centerline of the pipeline, assess macro type anomaly indications and geo-reference the aboveground features. In addition, soil resistivi-



Beg Sta No	End Sta No	CIS	PCM	DCVG	Table 1P/F	Table 2 P/F
52+50	57+45	300 mV Depression	20% Change	Multiple 60% IR	Failed	Failed
62+40	62+60	350 mV Depression	20% Change	Multiple 40% IR	Failed	Failed
68+30	69+00	300 mV Depression	40% Change	Multiple 50% IR	Failed	Failed
87+00	87+50	350 mV Depression	50% Change	Multiple 60% IR	Failed	Failed

ty survey was conducted at all areas of interest to determine if corrosivity of the soil may be a factor.

Based on the preliminary CIS information as shown in Graph 4, the pipe-to-soil potentials both ON and OFF are below the criteria for cathodic protection at several locations. This affirms our original assumption from the pre-assessment data that the line has not been well maintained in accordance to good corrosion engineering standards. It also affirms that the coating appears to be in poor condition which is indicated with the results of the PCM survey as shown in Graph 5; in other words, poor current attenuation.

The next indirect survey method used was DCVG because of the open R/W and the possibility of coating damage and interference conditions determined from the pre-assessment information. Several indications of 50% or greater were found at foreign line crossings and multiple indications were found in the woods and swamp area.

Tables 1 and 2 could be used to determine the prioritization of the indications as shown in the comparison table. Whether one uses the more conservative approach in Table 1 or the less conservative approach in Table 2, the results are the same.

Discussion

The goal of ECDA Tables 1 and 2 is to classify indications from the various aboveground surveys. Data from the Indirect Surveys requires integration of data and evaluation to determine how much of the pipeline is required to be examined. Excavation and visual examination of a pipeline is the most difficult and costliest part of the direct assessment process, yet provides the greatest confidence of all inspection techniques. ECDA is based on the premise that corrosion occurs at coating damaged areas with pipe-to-soil potentials being below the criteria for protection.

A decision must be made to dig or not to dig based on statistical sampling of indicators such as coating damage, history, operation, geography and confidence of the indirect surveys. A minimum number of excavations are required within each DA region as shown in Table 3. If corrosion is discovered that fails the remaining strength of corroded pipe, then additional excavations are required until this condition is no longer observed within the region.

Typical excavations in open right-of-way can cost approximately $5,000 each and run much higher in urban type regions. Good research work in the pre-assessment step is a primary way to control costs for unnecessary excavations. The level of pipeline information, history operating data and the use of risk assessment techniques affords an opportunity to control excavation costs if the corrosion probability can be determined. This will help determine the number of excavations required.

Conclusions

The objectives of this project were to evaluate and show that ECDA processes can evaluate effectively where to dig.

- Tables can be conservative or less conservative and still predict the number of digs required.
- Safeguards are built into the NACE ECDA RP 05/02 whereas it would be difficult or deliberate to invalidate the process.
- Good pre-assessment data is a must to minimize unnecessary digs.
- Good risk assessment modeling is another approach to minimize unnecessary digs. However, this is a subject that could be discussed in a later article.
- All tables predicted similar results.
- All of the required steps are necessary to ensure the integrity of the pipeline and remain within the sprit of the new Pipeline Integrity Management Rule in HCAs.
- Mitigation and prevention of these indications or anomalies can be accomplished by using good cathodic protection and engineering practices. However, where detrimental corrosion is found, recoat, repair or replacement of the pipeline may be required in accordance with industry-accepted practices. ***P&GJ***

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REFERENCES:

1. NACE RP05-02 External Corrosion Direct Assessment.
2. ASME B31.8 Supplement.
3. 49 CFR 192, Pipeline Integrity Management Rule in High Consequence Areas.
4. Unofficial PRCI Protocols for ECDA.