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INTERPRETATION OF INDIRECT INSPECTIONS DATA IN THE ECDA PROCESS

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ABSTRACT

The interpretation of the indirect inspection data is a critical factor in conducting a successful ECDA process. The data must be validated, discrepancies must be resolved, and indications must be identified, classified and prioritized, in order to select the sites for direct examinations.

This paper analyzes the various types of data provided by the indirect inspection tools and especially their interrelation. Additional types of indications related to AC and DC interference are also discussed. “Threat related” classification and prioritization criteria, as successfully applied on more than 50 gas pipelines in Ontario, are presented and rationalized. Possible error scenarios resulting from neglecting the interaction between various types of indications are developed from existing sets of data.

Keywords: External corrosion direct assessment, ECDA, close-interval potential survey, CIPS, close-interval survey, CIS, DC voltage gradient, DCVG, AC voltage gradient, ACVG, AC interference, AC-enhanced corrosion, ACEC, DC interference, DCI.

INTRODUCTION

Interpretation of indirect inspection data is a critical factor in conducting a successful external corrosion direct assessment (ECDA) process. The manner in which a pipeline operator interprets the results of the field surveys will have a significant impact on how he validates the data, how he selects the identification, classification and prioritization criteria and finally how he applies these criteria to the collected data.

This paper will discuss three aspects related to data interpretations:

- Dealing with unexpected data
- "Threat related" versus "Tool related" ECDA indications, with emphasis on "Double Dip" classification
- Interaction between indications

This discussion will be based on actual data collected during ECDA and close-interval potential survey (CIPS) applications in Canada. Possible error scenarios resulting from inappropriate interpretation of the real data will be analyzed. Most of these "possible errors" are self-evident and easily averted, however some may result in unnecessary excavations and high costs of the ECDA process.

Each error scenario is presented as a specific survey case, complete with recommendations for minimizing or even nullifying the error.

DEALING WITH UNEXPECTED DATA

A close interval survey was conducted in 2010 on a 323.9 mm (12") dia. natural gas line. The last section of the line is mainly protected by magnesium anode banks. The field crew started surveying this section by simultaneously interrupting the rectifiers and the influencing anode banks. Partial results of the survey are shown in Figure 1.

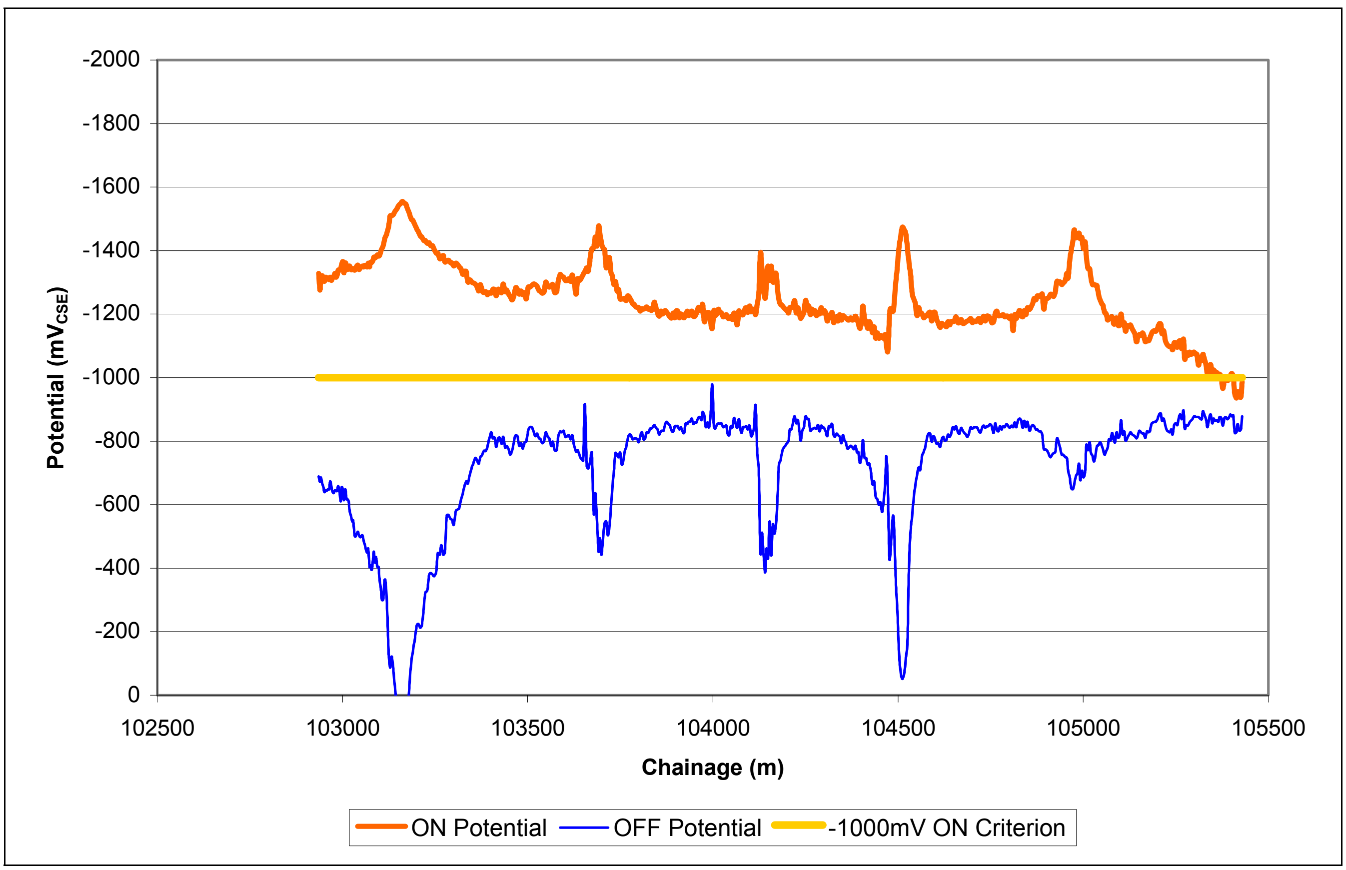

FIGURE 1 • 323.9 mm (12") Dia Line. Recorded ON/OFF Potentials

The pipeline displayed local OFF potentials as low (i.e. electropositive) as $+136mV_{CSE}$, with average values around $-800mV_{CSE}$. In an ECDA process, such potentials would be initially classified as "severe" CIPS indications. Furthermore, if the operator could not explain such extreme behavior, a direct examination would be required. Are these potentials real or a measurement error? Assuming they are real, would a direct examination be required? These are two extremely important questions which must be answered by the pipeline operator when interpreting the field data.

The actual reason for the extremely low potentials was rectification of the AC induced voltages, during magnesium bank interruption. This rectification phenomenon was presented by the authors in a previous paper[1] – see Figure 2.

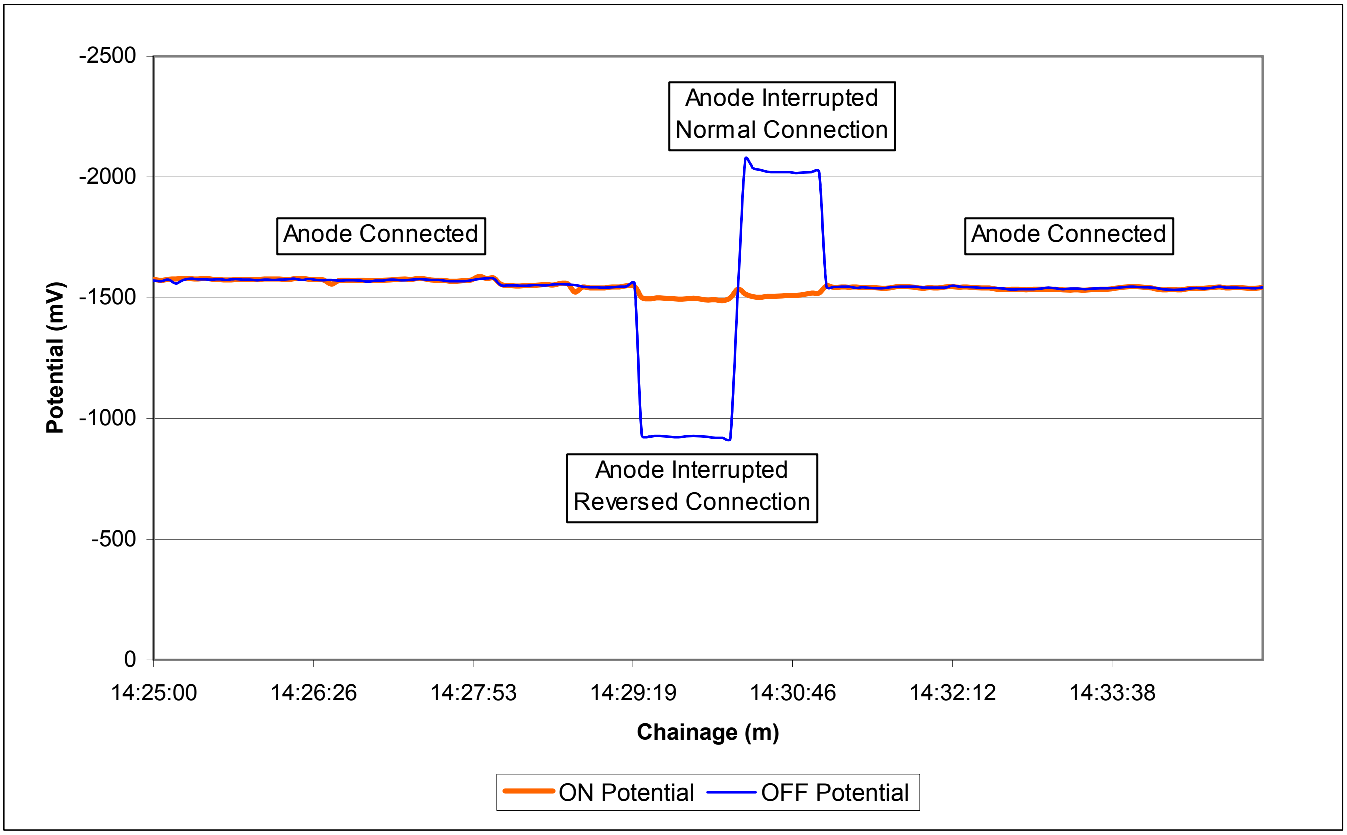

FIGURE 2 • 219 mm (8") Dia Line. Rectification of AC Voltage by the GPS Interrupter

The OFF potential shifted by +600mV or -600mV, depending on how the interrupter leads were connected inside the test post.

The interrupter is seen as a diode shorted during the ON cycle and acting as a small rectifier during the OFF cycle – see Figure 3.

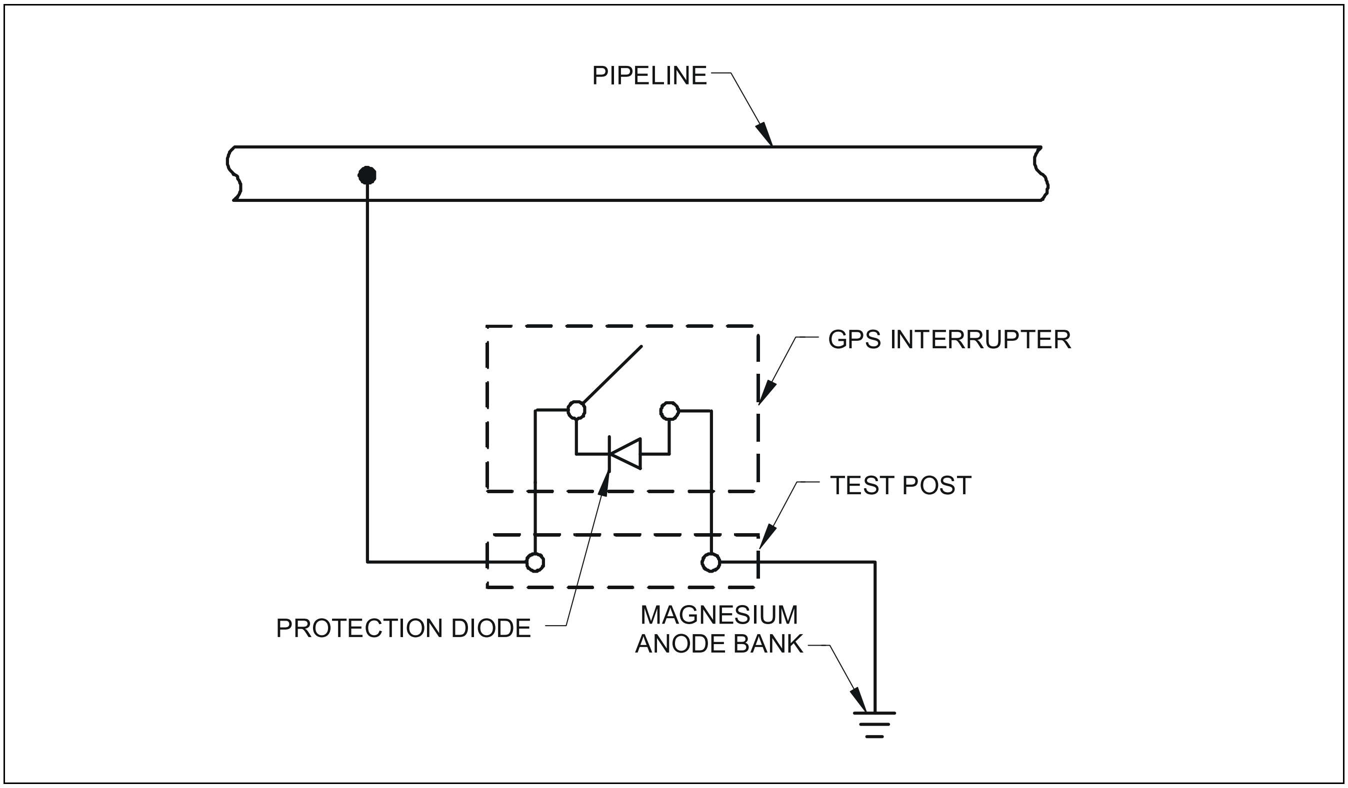

FIGURE 3 • Rectification by Protection Diode during the OFF Cycle

During the survey, the interrupter was connected as shown, severely reducing the protection level. The answers to the two questions would have been:

1. "The potentials were real and the line was actually unprotected for an extremely short period (i.e. several hours)" and,
2. Subsequently for such an extremely short exposure, "No direct examination is required".

"THREAT RELATED" VERSUS "TOOL RELATED" ECDA INDICATIONS

Today, practice in the ECDA process is to identify "tool related" indications. A pipeline may display CIPS indications, DC voltage gradient (DCVG) indications, AC voltage gradient (ACVG) indications, etc. To avoid "double dipping" (i.e. having both indirect inspection tools pointing to the same indication), the SP0502-2007[2] requires that indications shall be provided by complementary tools. For example an ECDA process cannot rely only on DCVG and ACVG surveys, which are expected to provide the same data.

The problem is that some indirect inspection tools may provide several types of information. For example: the CIPS is the only tool allowing the protection level to be assessed, but it also may provide valuable data regarding the presence and size of a holiday and the risk of DC interference. As such, when using the term "CIPS" indication (a "tool related" indication), the operator should keep in mind that a low (i.e. electropositive) potential is a "protection level-threat related" indication, a drop in potential could be a "coating holiday - threat related" indication and a low or reversed ON-OFF potential shift is a "DC interference – threat related" indication.

The following example demonstrates how a DCVG indication could be identified from CIPS data, which could result in a “double dipping” situation.

Figure 4 shows the results from an integrated CIPS/DCVG survey in southern Ontario.

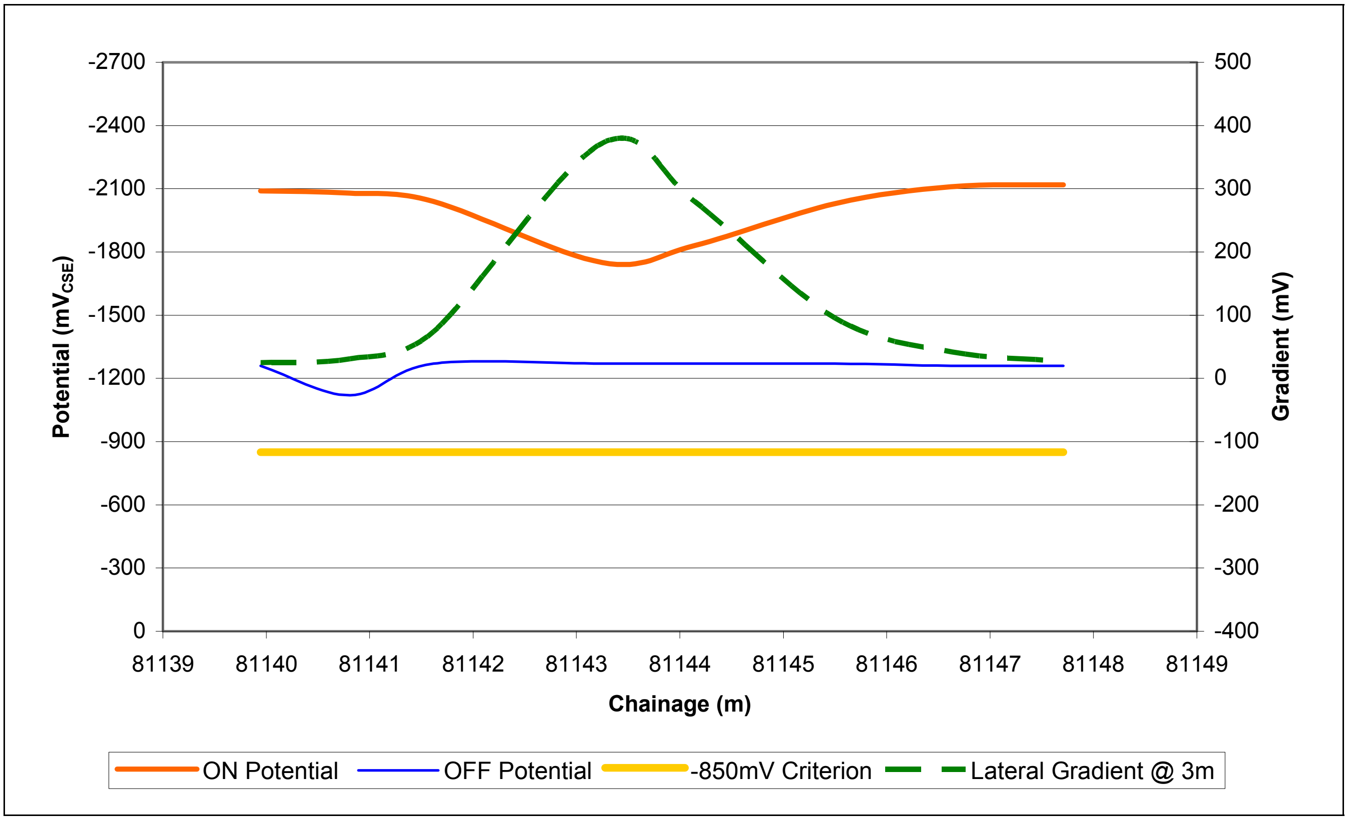

FIGURE 4 • 406.4 mm (16") Dia Gas Line. CIPS/DCVG Data

Figure 5 shows the same measured lateral DCVG profile versus the calculated DCVG longitudinal profile. The DCVG longitudinal profile was obtained from the pipe-to-soil potential data plotted in Figure 4, by assuming that the gradient between two points on the pipeline equals the difference between the two pipe-to-soil potentials.

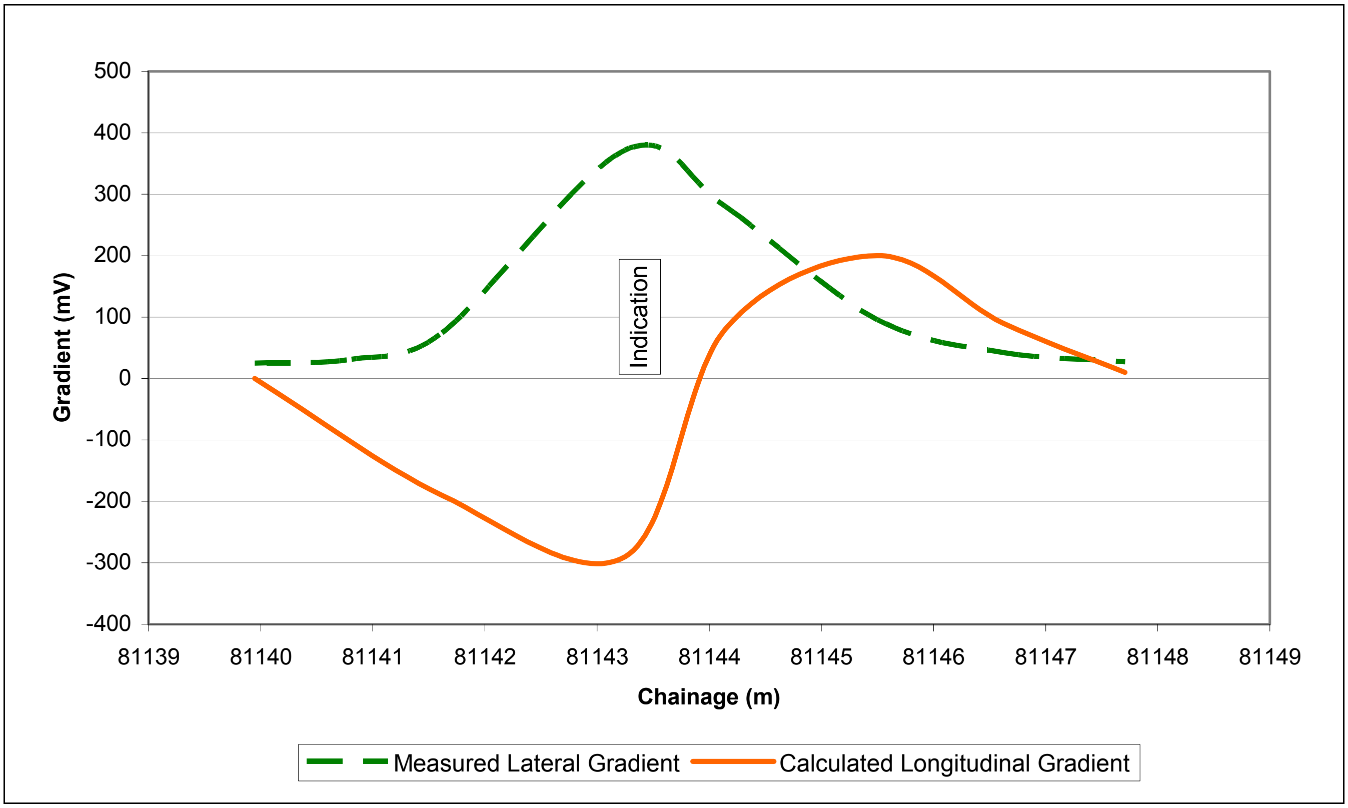

FIGURE 5 • 406.4 mm (16") Dia Gas Line. DCVG Indication Identified from CIPS Data

Both profiles identify the same holiday.

In a very possible scenario, a large holiday in a protected area would be classified as a "severe" CIPS indication based on the sharp drop in potential and also as a "severe" DCVG indication, based on the measured gradient. Subsequently, the two severe indications would have to be prioritized as "Immediate Action Required" requiring direct examination, although the line is fully protected and no corrosion is expected.

To avoid this type of "double dipping" only the DCVG indication should be prioritized. The drop in potential displayed in the CIPS profile should be seen as a confirmation of the presence of a holiday and not an independent CIPS indication.

INTERACTION BETWEEN INDICATIONS

Even independent indications could interact when assessing the corrosion risk for a pipeline. This interaction should be considered when prioritizing the indications. The best example is the risk of AC enhanced corrosion (ACEC). According to literature[3], there is no risk of ACEC for AC current densities less than 20A/m^2, the ACEC is unpredictable for AC current densities between 20 and 100 A/m^2 and ACEC is to be expected for AC current densities greater than 100A/m^2. The highest corrosion rates were found on steel samples having a surface area in the range of 1 to 3 cm^2, therefore an area of 1 cm^2 is typically selected as the worst case value for identifying ACEC indications.

The maximum AC current density at a 1 cm^2 holiday can be calculated using the equation[4]:

$$i_{ac} = \frac{8 \times V_{ac}}{\rho \times \pi \times d} \qquad [1]$$

where: i_{ac} = AC current density (A/m^2)
V_{ac} = AC induced voltage (V)
ρ = soil resistivity (Ω-m)
d = diameter of holiday = 0.0113 m

The calculated maximum current density may be used to identify and classify ACEC indications, as follows:

- Minor: AC current density less than or equal to 50 A/m^2
- Moderate: AC current density higher than 50 A/m^2 and less than 100 A/m^2
- Severe: AC current density more than 100 A/m^2

It is easy to see from equation [1] that the risk of ACEC decreases with increased diameter of the holiday, therefore an ACEC indication in conjunction with a minor DCVG indication would have to be prioritized higher than the same ACEC indication in conjunction with a severe DCVG indication. In other words, two independent severe indications (i.e. ACEC and DCVG) present little risk to pipeline integrity, when the interaction between indications is considered.

An excerpt of a prioritization table, which considers the interaction between such indications, is shown in Table 1.

TABLE 1 • Excerpt from a Prioritization Table

Coating Holiday (DCVG Indication)		Prioritization							
		Prior History of Corrosion (PHC)				AC Enhanced Corrosion (ACEC)			
		SV	MD	MN	Nil	SV	MD	MN	NI
		1	2	3	4	17	18	19	20
DCVG-SV	1	I	I	S	S	N/A	N/A	N/A	S
DCVG-MD	2	I	S	M	M	N/A	N/A	N/A	M
DCVG-MN	3	M	M	M	M/N*	I	S	M	M/N*
DCVG-BT	4	N	N	N	N	I	S	M	N
DCVG-NI	5	N	N	N	N	I **	N	N	N

* Consider downgrading isolated minor DCVG indications suspected to be old magnesium anodes to "No action required".

Legend:

SV =	Severe indication	**I** =	Immediate action required
MD =	Moderate indication	**S** =	Scheduled action required
MN =	Minor indication	**M** =	Suitable for monitoring
BT =	Below threshold	**N** =	No action required
NI =	No indication	**N/A** =	Not Applicable

The "Not Applicable" instead of "No Action Required" prioritization status for moderate and severe DCVG indications in conjunction with ACEC indications was selected to avoid a potential conflict with the requirements of paragraph 5.2.2.1.2 of NACE Standard SP0502-2008, which prioritizes multiple severe indications in close proximity as "Immediate Action Required".

The risk of pipeline exposure to DC interference (DCI) also decreases with the size of holiday, or the severity of the DCVG indication.

CONCLUSIONS

Three cases were presented to emphasize the importance of the interpretation of the indirect inspection data in conducting a successful ECDA process.

In the first case, the pipe was unprotected during the survey, with potential reaching +130mV$_{CSE}$. An in-depth data analysis indicated it was an extremely short exposure due to rectification of AC current and subsequently no further action was required.

The second case developed a possible error scenario, based on actual survey data. The common practice of identifying a sharp drop in potential as a CIPS indication may result in two indirect inspection tools (i.e. CIPS and DCVG) pointing to the same holiday defect indication. Subsequently, a severe coating defect in a well protected area could be erroneously prioritized as “Immediate action required”. To avoid this type of “double dipping” we recommend that only the DCVG indication should be prioritized. The drop in potential displayed in the CIPS profile should be seen as a confirmation of the presence of a holiday and not an independent CIPS indication.

The third case analyses the interaction between indications and how it impacts the selected prioritization criteria. Since the risk of AC enhanced corrosion (ACEC) decreases with increased diameter of the holiday, an ACEC indication in conjunction with a minor DCVG indication would have to be prioritized higher than the same ACEC indication in conjunction with a severe DCVG indication. The risk of pipeline exposure to DC interference (DCI) also decreases with the size of holiday, or the severity of the DCVG indication.

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