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Challenges in Analyzing ECDA Indirect Inspections Data

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ABSTRACT

The analysis of indirect inspection data is a critical factor in conducting a successful External Corrosion Direct Assessment (ECDA) process. Any "out of range" data must be validated prior to being considered an ECDA indication. Furthermore, standard methods of validating the accuracy of the field data must be reviewed when special conditions are present.

This paper covers a number of lessons learned by dealing with less well-known sources of measurement error, during nine years of ECDA application on more than 100 projects.

Topics like "clipped" gradients during the DC Voltage Gradient (DCVG) Survey, AC current drain by well casings during influence testing, and sharp drops in potential indicating the presence of an underground isolating flange are discussed in detail in this paper.

Keywords: ECDA, CIPS, DCVG, AC interference, DC interference, isolating flange.

INTRODUCTION

The quality of the indirect inspection data is a critical factor in conducting a successful ECDA process. False indications can result in high cost excavations at the wrong locations, while missed severe indications could result in an immediate threat to pipeline integrity.

This paper covers three additional lessons learned by dealing with less well-known sources of measurement error, during nine years of ECDA application on more than 100 projects. Other possible sources of errors were discussed by the authors in previous papers.[1,2]

Each source of error will be presented as a specific survey case, complete with recommendations for minimizing or even nullifying the error.

AVOIDING ERRORS DUE TO "CLIPPED" DC GRADIENTS

An integrated close interval potential/direct current voltage gradient (CIPS/DCVG) survey[3] was conducted in 2012 on an NPS2 gas lateral in northern Ontario as part of the ECDA program. The pipeline is protected by directly connected magnesium anodes. An existing resistance bond, connected between the lateral and mainline, was draining 1.1A back to the mainline impressed current systems. The integrated CIPS/DCVG survey on the lateral was coordinated with the annual CIPS survey on the mainline, which is operated by a different owner. Interrupters were installed at each foreign influencing rectifier. Data loggers were installed at remote test posts to facilitate telluric compensation. The recorded gradients in the proximity of the foreign groundbed are shown in Table 1 and the corresponding results of the survey are plotted in Figure 1. The line shown at -1000 mV_{CSE} represents the identification criterion for CIPS indications on pipelines protected by directly connected magnesium anodes, with all influencing rectifiers turned OFF.

Table 1
Excerpt of CIPS/DCVG Data with "Clipped" DCVG gradients

Chainage (m)	ON Potential (mV)	OFF Potential (mV)	Lateral Gradient @ 3m	
			ON	OFF
615.7	-2758	-1335	-382.7	-27.4
616.3	-2398	-1307	-435.7	-51.8
617.1	-2157	-1300	-500.0	-54.0
617.8	-2110	-1305	-500.0	-41.6
618.9	-2683	-1359	-139.3	-19.4
620.1	-2730	-1378	-159.8	-15.9

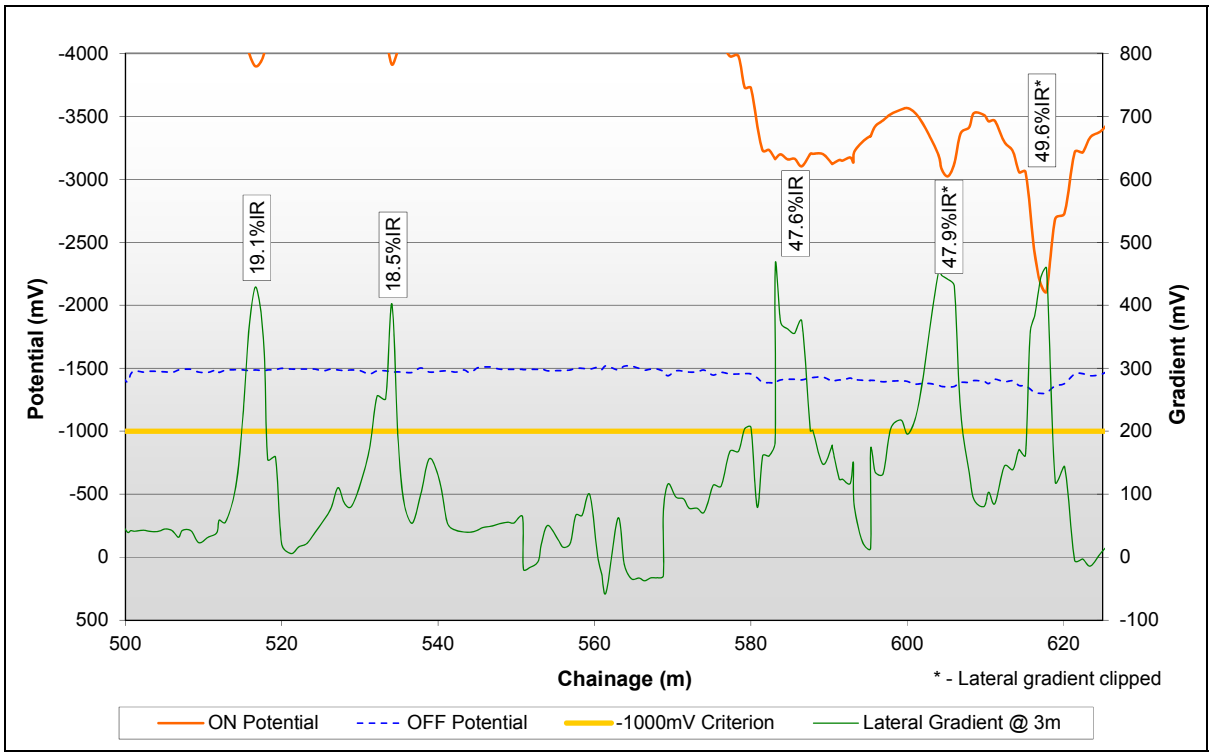

Figure 1: NPS2 Line. Results of CIPS/DCVG Survey with "Clipped" DCVG Gradients

At two locations (i.e. chainage 617.1 m & 617.8 m), the ON gradient was "clipped" at the limit of the measurement range of the "Hexcorder Millenium"† two-channel data logger (i.e. -500 mV_{CSE}), resulting in a lower %IR and an underestimation of the coating damage. These locations were marked on the graphs using an asterisk (*).

† Trade name.

The easiest way to deal with this type of error is to turn OFF the foreign rectifier energizing the influencing groundbed and to conduct a separate DCVG survey. Unfortunately, the CIPS survey on the foreign line was on a tight schedule and re-installing interrupters, de-energizing a rectifier and waiting for the ECDA crew to perform a second DCVG survey would have been a major inconvenience.

As such, an increase to the next severity category in terms of %IR was conservatively applied at these locations as an alternative solution, as required by paragraph 4.3.2.3 of NACE Standard SP0502-2010.[4] For example, the "clipped" DCVG indication at chainage 617.1 m, displaying a %IR of 49.6% and classified as "moderate" was up-graded to a "severe" DCVG indication. Furthermore, the prioritization of these indications was carefully reviewed.

Should a severe CIPS indication be identified at the same location and should a "double up-grade" of the "clipped" DCVG indication (i.e. from "minor" to "severe") result in prioritization as "Immediate Action Required", then consideration must be given to "double up-grade" the indication or to conduct an independent DCVG survey. However, no such cases were identified, since a very high ON gradient is typical for a "pick-up" area where the pipe is normally fully protected.

DEALING WITH A POSSIBLE UNDERGROUND ISOLATING FLANGE

During the integrated CIPS/DCVG survey on the same NPS2 gas lateral, a spool wire break occurred at chainage 1145.2 m. The original wire connection was at the end of the line (i.e. chainage 1712.9 m) and the survey was conducted upstream. The wire was reconnected to test post TB3 at chainage 1450.3 m and the survey continued upstream to test post TB2 at chainage 631.4 m, where the wire was reconnected for the remainder of the survey. The results of the survey are shown in Figure 2.

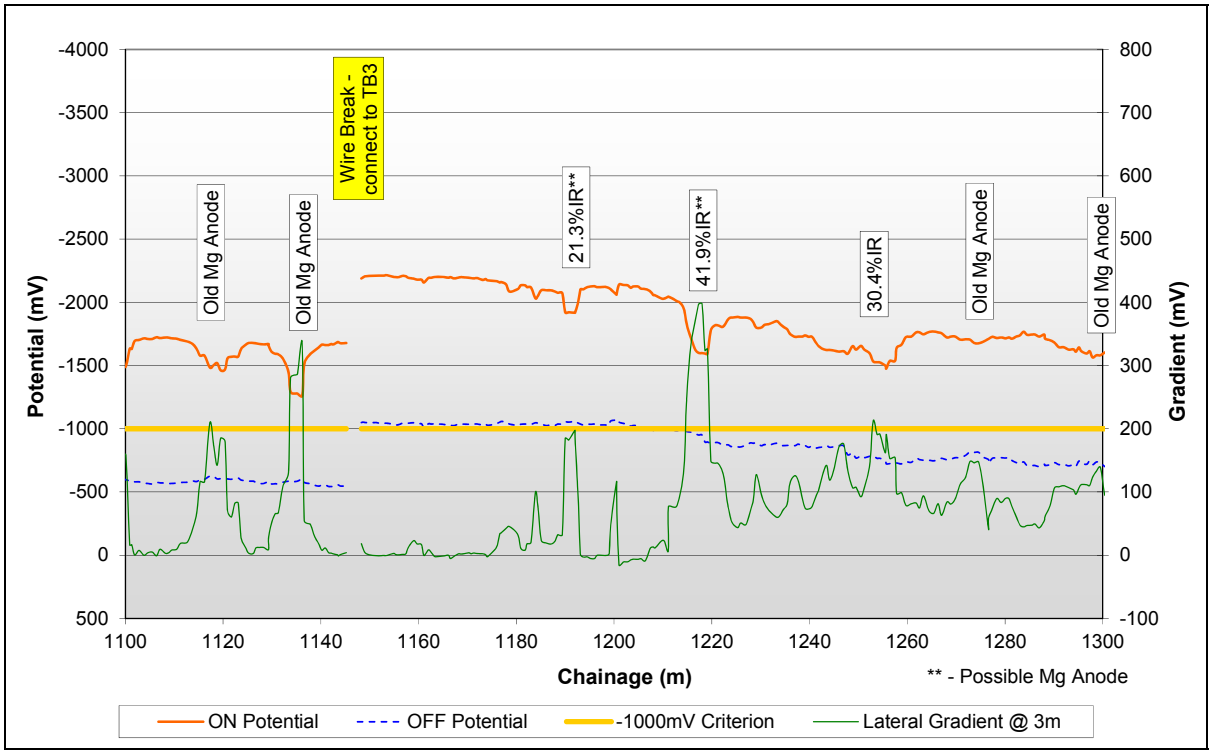

Figure 2: NPS2 Line. Ch. 1000 to 1500 m. CIPS/DCVG Data

The significant potential difference recorded at the wire break (i.e. 500 mV), affecting both the ON and OFF readings, needed to be addressed. A difference in the ON potential when changing the connection point is normal, but even on an NPS2 line the metallic longitudinal I-R drop is not expected to reach 500 mV.

Furthermore, a similar I-R drop in the OFF potential required a major influencing rectifier to be left ON during the survey, contradicting the results of the influence testing.

A second possibility was the presence of an underground isolating flange between TB3 and the end of the line. Any potentials measured upstream of such an isolating flange, with the spool wire connected at the end of the line, would have been erroneous readings (i.e. the potential of the last holiday downstream of the flange measured with respect to a remote reference electrode moving away from the holiday). The true potentials for this section would have been within the -500 mV_{CSE} range, as measured with the spool wire connected to TB3. Undetected DC interference would have been an additional threat on an electrically discontinuous line.

In order to address this possibility, continuity testing was immediately conducted in conjunction with direct examinations (DE) at indications prioritized as "Immediate Action Required" and a short clearing at a cased crossing. The results are shown in Table 2.

Table 2
Continuity Testing

From	To	DC Resistance (Ω)	DC Potential (mV)	Notes
Ch. 1429.4 m (DE#3.2)	Ch. 1410.2 m (DE#3.1)	0.2	0.0	-
	Ch. 1509.0 m (DE#4)	0.2	0.1	-
	Ch.1517.7 m (DE#5)	0.2	0.1	-
	Ch. 1450.3 m (TB3)	172,000	-161.0	Damaged test wire

The testing indicated that the line is electrically continuous and the potential difference was a result of a damaged wire at test post TB3. The test wire was repaired, the section from the wire break to test post TB2 was re-surveyed and the pipe was found fully protected along this section.

AVOIDING ERRORS DURING INFLUENCE TESTING

The purpose of the influence testing is to confirm that the lines are "clean" during the CIPS, meaning that all influencing rectifiers were interrupted simultaneously and that any dynamic stray current activity (i.e. telluric currents) would be compensated in the final results

The test is based on the fact that a single-phase rectifier does not generate a perfect DC current (i.e. like a battery), but it introduces a significant 120 Hz ripple.

If the pipe-to-soil potential is recorded or displayed on an oscilloscope, then the magnitude of various frequencies, including 120 Hz, can be determined. When the recording is done during the OFF cycle, and no 120 Hz ripple is found, it indicates that no single-phase influencing rectifier is active during the recording. Similarly, a three-phase rectifier has a 180 Hz ripple, however sometimes the signature of three-phase rectifiers cannot be accurately detected as it coincides with harmonics of the 60 Hz AC induced voltages.

Influence testing was conducted during an integrated CIPS/DCVG survey on a gas storage pool in southern Ontario, as part of the ECDA program. During the test, all rectifiers affecting the surveyed lines were interrupted simultaneously using GPS synchronized interrupters. Pipe-to-soil potential waveforms were recorded during the OFF cycle (see Figure 3) and frequency analysis was conducted using commercially available software to calculate the amplitude of various frequency components in order to identify signatures of influencing single-phase or three-phase rectifiers left ON or out of synchronization.

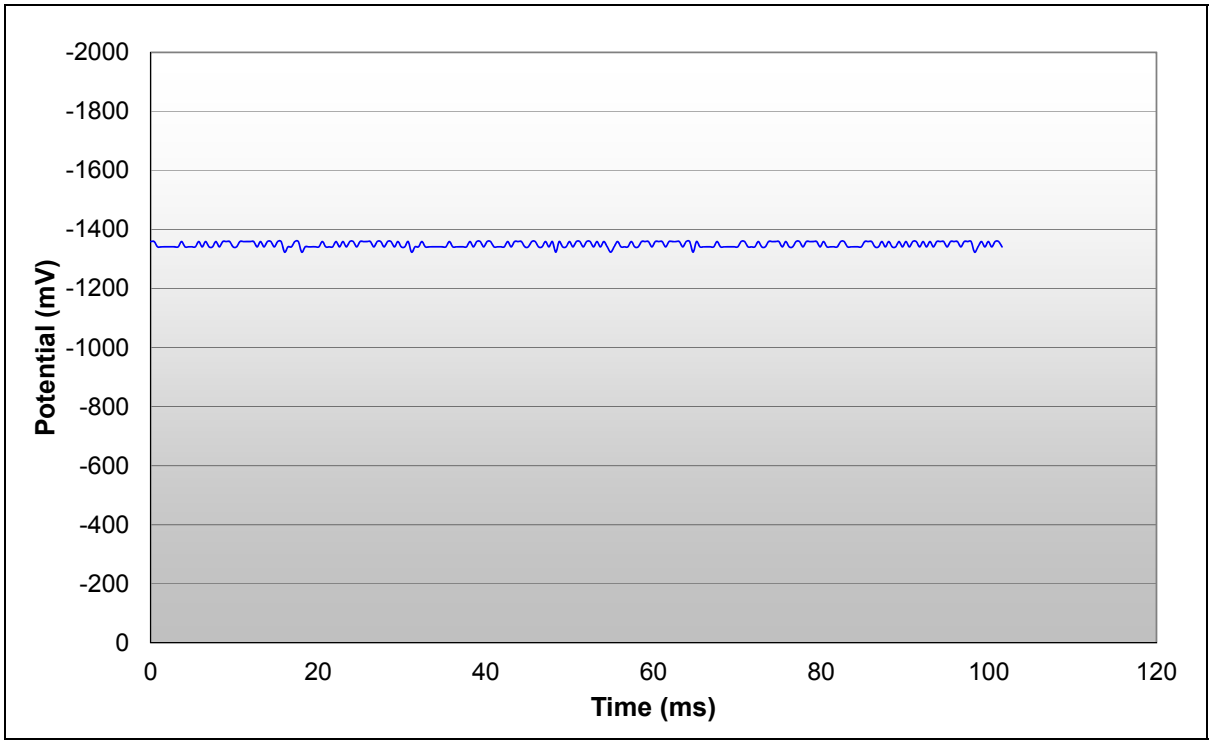

Figure 3: Influence Testing. OFF Cycle Waveform. Pipe-to-Soil Potential

The frequency analysis indicated a DC component of -1302 mV_{CSE}, a very low amount of 60 Hz AC induced voltage (i.e. 3 mV), and negligible 120 and 180 Hz components (i.e. 1 mV each), as shown in Figure 4.

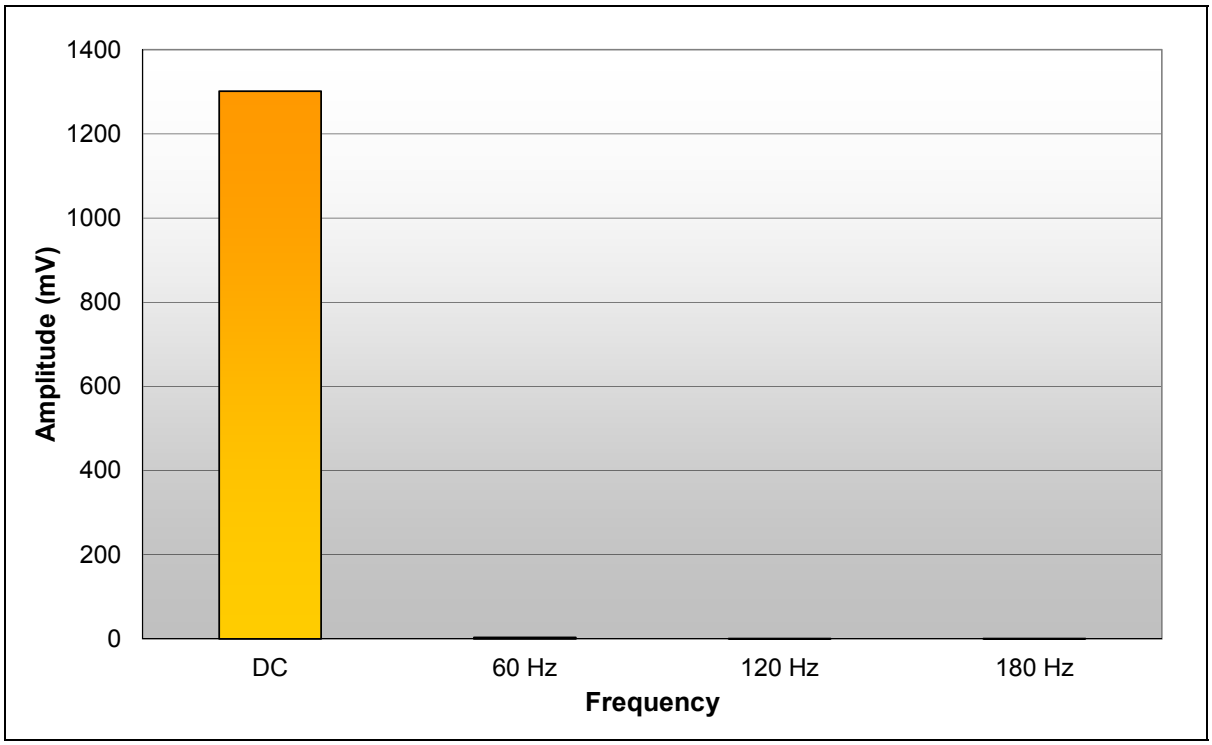

Figure 4: Influence Testing. OFF Cycle Waveform. Frequency Spectrum

The lack of 120 Hz and 180 Hz components indicated that there was no residual DC current from single-phase or three-phase rectifiers influencing the pipelines during the OFF cycle.

However, the highly electronegative OFF potential (i.e. -1302 mV_{CSE}) suggests influence from un-identified rectifiers or magnesium anodes.

An in-depth analysis of the system configuration indicated that the accuracy of the influence testing is severely limited by the presence of the well casings, connected to pipelines via resistors. Part of the AC voltage is discharged to ground via the casings, resulting in very low 120 Hz and 180 Hz components.

Subsequently, the regular influence testing was not considered reliable on this type of system and a DC coupon was installed at the location of a direct examination to validate the protection level.

Alternatively, the influence testing may be conducted after temporarily disconnecting the well casings. Note that the DCVG survey was conducted as an independent survey after disconnecting the casings and de-energizing all close groundbeds.

CONCLUSIONS

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

In the first case, the ON gradient was "clipped" at the limit of the measurement range of the data logger (i.e. –500 mV_{CSE}), resulting in a lower %IR and an underestimation of the coating damage. The proximity to a foreign groundbed was identified as the source of error. Such errors may be eliminated by de-energizing the foreign rectifier or compensated by up-grading the severity of the DCVG indication.

The second case developed a possible "worst case" scenario, based on actual survey data. A significant potential difference recorded at a wire break (i.e. 500 mV) and the subsequent sub-criterion OFF potentials within the -500 mV_{CSE} range were consistent with the presence of an underground isolating flange, resulting in an immediate threat to pipeline integrity. The pipeline operator was notified and continuity testing was immediately conducted. The testing indicated that the line was electrically continuous and the potential difference was a result of a damaged wire at the reconnection test post.

In the third case, the results of the influence testing indicated that the line was "clean", but the highly electronegative OFF potentials (i.e. -1302 mV_{CSE}) suggested influence from un-identified rectifiers or magnesium anodes. The presence of well casings discharging AC voltage to ground was identified as the main factor reducing the accuracy of the influence testing. A DC coupon was installed at the location of a direct examination to validate the protection level.

REFERENCES

1. S. M. Segall, R. A. Gummow, R. G. Reid, "Ensuring the Accuracy of Indirect Inspections Data in the ECDA Process", Corrosion 2010, Paper No. 10061, San Antonio, Texas.

2. S. M. Segall, R. A. Gummow, J. Shore, "Interpretation of Indirect Inspection Data in the ECDA Process", Corrosion 2010, Paper No. 17713, Houston, Texas

3. S. M. Segall, R. A. Gummow, R. G. Reid, "Use of an Integrated CIPS/DCVG Survey in the ECDA Process", Corrosion 2006, Paper No. 06193, San Diego, California

4. NACE Standard Recommended Practice SP0502-2010, "Pipeline External Corrosion Direct Assessment Methodology", Houston, 2010.