Paper No.
10657

Improvements in the Use of Indirect Inspection Tools and Data Interpretation

S.M Segall, P. Eng.
Corrosion Service Company Limited
9-280 Hillmount Rd.
Markham, ON, Canada L6C 3A1

R.A. Gummow, P. Eng.
Corrosion Service Company Limited
9-280 Hillmount Rd.
Markham, ON, Canada L6C 3A1

D. Fingas; P. Eng.
Corrosion Service Company Limited
9-280 Hillmount Rd.
Markham, ON, Canada L6C 3A1

Cory Bradshaw, P. Eng.
TransCanada Pipelines Limited
450 – 1st Street SW,
Calgary, AB, Canada T2P 5H1

ABSTRACT

This paper covers various methods for dealing with sources of errors affecting the accuracy of the Direct Current Voltage Gradient (DCVG) coating defect identification and sizing tool. Topics reviewed in detail include: eliminating the influence of local soil resistivity and varying pipe depth on the calculation of the %IR severity ranking index and using the DCVG in conjunction with an AC Current Attenuation (ACCA) survey.

Keywords: External Corrosion Direct Assessment (ECDA), Close Interval Potential Survey (CIPS), Direct Current Voltage Gradient (DCVG), percentage IR (%IR), AC Current Attenuation (ACCA) survey, soil resistivity, pipe depth, groundbed gradients.

INTRODUCTION

The accuracy of the indirect inspection data and the quality of the data interpretation are critical factors in conducting a successful ECDA program. Knowing the limitations of each indirect inspection tool, identifying the sources of error and finally adapting the data processing and interpretation to deal with these sources of errors are essential aspects of the continuous improvement of the ECDA process.

The DCVG survey is now considered the only tool which can accurately evaluate the size of a holiday, using the percentage IR (%IR). The %IR is calculated as a ratio between gradient and pipe-to-soil potentials, both measured with respect to remote earth, as described in NACE Standard TM0109-2009.[1]

However, differences between the soil resistivity at the test station where the pipe-to-soil potential was measured with respect to remote earth and the local soil where the DCVG detected the holiday can result in significant errors. Furthermore, the calculated percentage IR does not account for the pipeline depth.

An additional challenge is how to assess the coating quality and the protection level at inaccessible areas, such as highways, rivers, etc.

This paper covers lessons learned when dealing with these challenges.

Each challenge lesson will be presented based on the original survey case, complete with recommendations for avoiding possible errors.

ACCOUNTING FOR PIPELINE DEPTH IN %IR CALCULATIONS

An ECDA process was conducted on a NPS16 gas pipeline in Canada in 2005.[2] At the time, a proprietary formula was developed to calculate the %IR using the lateral gradient measured at 3 m and the pipe-to-soil potential measured on top of the pipe. However, the formula used a “standard” cover of 1.2 m. A moderate DCVG indication (i.e., 55.2%IR) was identified at a ditch crossing, with the pipeline fully protected along its entire length (i.e., no CIPS indications). The high %IR was attributed in part to the gradient distortion produced by the reduced soil cover (i.e., 0.5 m). Considering the difficulties associated with excavating the pipe it was imperative to re-assess the severity of the coating damage under reduced cover. Subsequently, a different technical approach was developed for this re-assessment.

The gradient potential was measured at the holiday every meter until it stabilized and the results were plotted as shown in Figure 1 (green line).

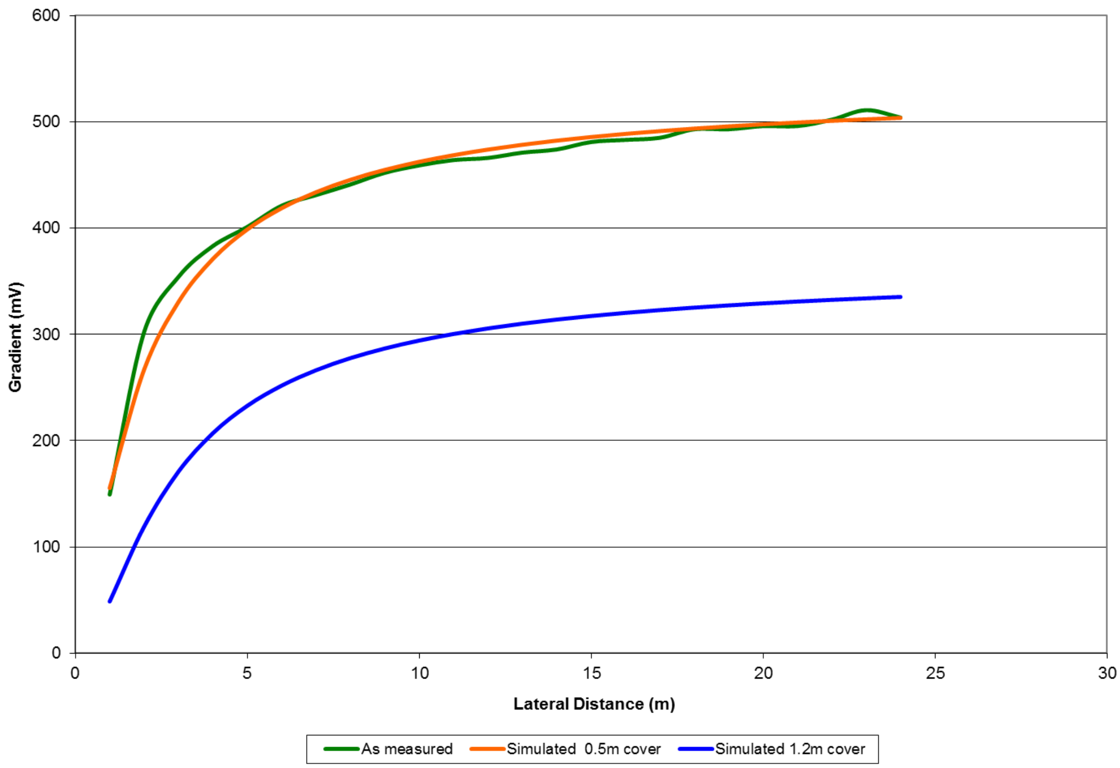

Figure 1: Influence of Reduced Cover on Severity of a Coating Defect.

The measured gradient was then matched to a simulated gradient produced by a 50 cm^2 holiday with a 0.5 m cover (orange line). The gradient produced by the same sized holiday, but with the 1.2 m cover, was then calculated and plotted (blue line). The reduction in cover resulted in an increase of approximately 48% (160 mV) in the lateral gradient at 3 m. The %IR was adjusted accordingly, dropping to 40%.

The process was work intensive and using it at each holiday was not an option. As such, the proprietary formula was further developed to account for the pipe depth.

Having such a formula was a step in the right direction, but it raised new questions. As the direct assessment methodology extended to larger diameter pipelines (e.g., NPS36 and higher), a holiday located at 12:00 position with 1.2 m cover would be at a depth of 1.2 m, while a holiday located at 6:00 position would be at least at 2.1 m depth. What value to use? Would selecting the 6:00 position be a conservative approach, as it would result in a higher %IR? There are no simple answers to cover all the projects. For well coated lines, with a small number of holidays and good protection levels, using the maximum depth would be the preferred approach (i.e., conservative, without increasing significantly the cost of the assessment). However, on poorly coated pipelines, over-prioritizing a holiday at 12:00 position by assuming the maximum depth, may result in selecting a minor indication for direct examination, instead of a severe indication, located at 6:00 position. Additional testing, involving detailed gradient mapping around the holiday for locations displaying severe CIPS indications, is typically required to deal with these situations.

ACCOUNTING FOR LOCAL DIFFERENCES IN SOIL RESISTIVITIES

An ECDA process was conducted on a NPS8 gas pipeline in Canada and the proprietary formula was used to calculate the %IR in an integrated CIPS/DCVG survey.[3]

As the survey progressed in a rocky area, the pipe-to-soil potential ON/OFF shifts dropped below 20 mV and the calculated %IR reached values close to 90% (see chainage 1100m on Figure 2).

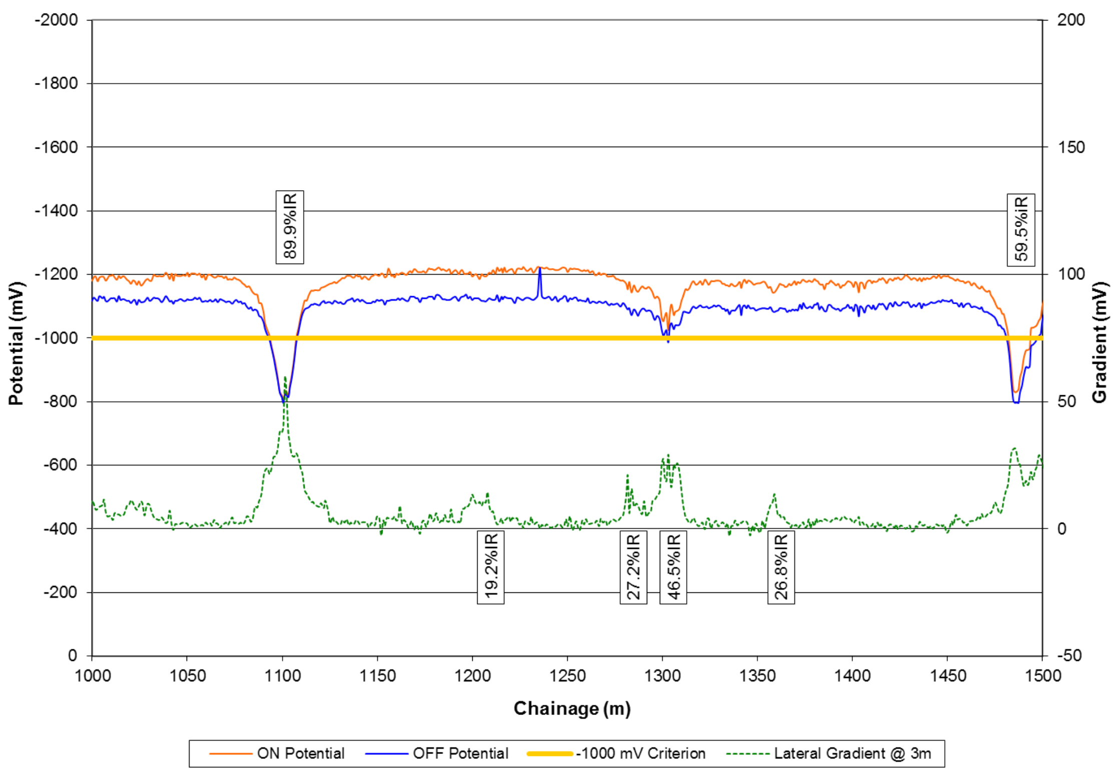

Figure 2: CIPS/DCVG Profile in High Resistivity Area.

Although the calculation method had previously been tested in the field during several years of ECDA applications and had been found to give excellent results, it was never used where such small potential shifts were encountered. Installing a temporary groundbed to increase the shifts was not an option, since the high anodic gradients would have obscured the detection of the smaller gradients produced by the coating holidays. Subsequently, it was decided to validate the calculation method by actually measuring the lateral gradient and the total potential shift with respect to remote earth at two DCVG indications (i.e. chainage 1101.6 m and chainage 1485.7 m).

The exact value of the %IR was then calculated using the fundamental Equation 1:

$$\%IR = \frac{\Delta G_{OL-RE}}{\Delta V_{RE}} \tag{1}$$

Where:

ΔG_{OL-RE} = Lateral gradient shift measured to remote earth

ΔV_{RE} = Pipe-to-soil potential shift measured to remote earth

The results, shown in Table 1, confirmed the validity of the %IR calculations with small potential shifts in high resistivity soil conditions.

Table 1: Validation of %IR Calculations in High Resistivity Soils.

Chainage (m)	ΔV_{RE} (mV)	ΔG_{RE} (mV)	%IR	
			Measured	Calculated
1101.6	123	117	95%	89.9%
1485.7	103	65	63%	59.5%

Using the regular practice of interpolating pipe-to-soil potentials measured to remote earth at adjacent test posts would have resulted in completely erroneous values, since the closest test posts were located in relatively low resistivity areas where the pipe-to-soil potential shifts were 230 mV up-stream and 136 mV down-stream.

To avoid errors in interpolating pipe-to-soil potentials measured to remote earth at test posts installed in areas with different soil conditions, it is recommended to either measure the value locally or use a calculation method which accounts for the local conditions.

ASSESSING THE COATING QUALITY AT INACCESSIBLE AREAS

An integrity assessment was conducted in 2016 on several transmission pipelines in Canada using ECDA methodology. The pipelines crossed a number of major highways, rivers and other areas, with limited access. For example, ensuring traffic control on a two-lane highway, drilling and repairing holes at 1 m spacing to ensure good contact during a DCVG or an ACVG survey would have increased significantly the logistical difficulty and assessment cost. As such, a combined ACCA/DCVG survey method was successfully used to assess the coating quality at areas defined as “inaccessible” for practical purposes.

Initially, the DCVG survey was conducted at all accessible areas, including the sections adjacent to the inaccessible areas. Then, AC attenuation (ACCA) surveys were conducted adjacent to the short inaccessible sections to estimate the coating quality, by comparing the signal attenuation across the section under assessment with the attenuation in adjacent sections, which displayed good coating quality (i.e., no DCVG indications).

Two survey profiles are shown in Figure 3 and Figure 4. The signal strength in mB-mA is shown on the vertical axis and the pipeline chainage on the horizontal axis. The trendlines for each section (i.e., upstream, across and downstream) are displayed on the graph, together with their linear equations and the R^2 coefficients. The slopes of the trendlines represent the attenuation per meter for each section.

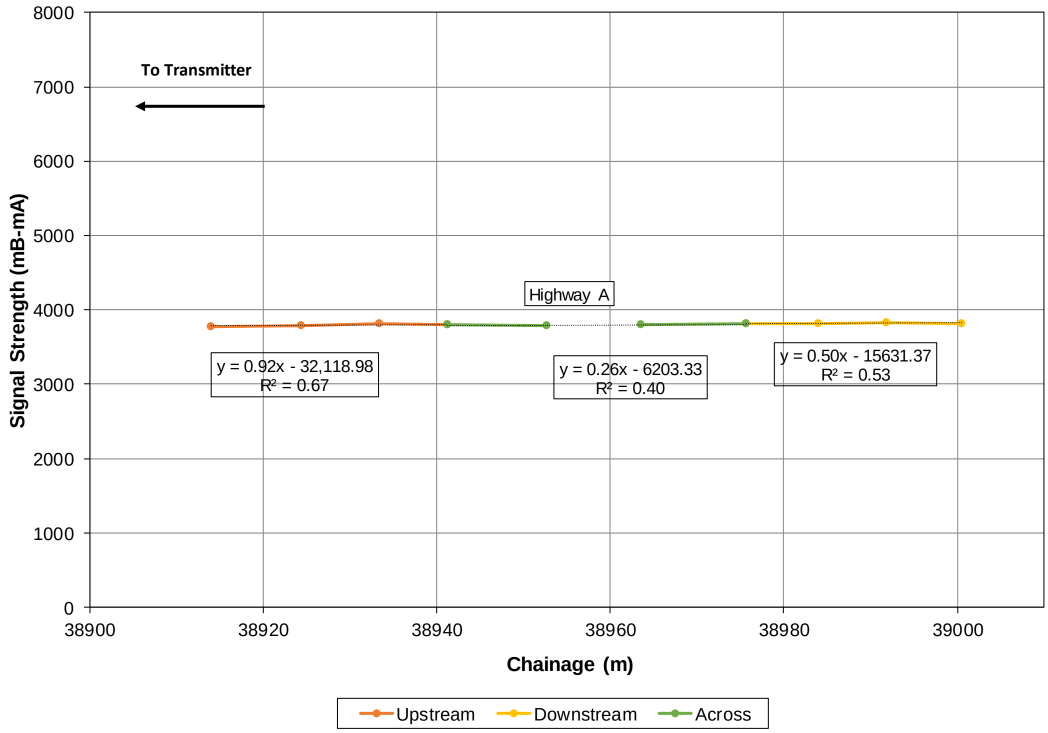

Figure 3: Highway A. AC Current Attenuation Data.

In this survey profile, the attenuation per meter is relatively constant along each section and does not exceed 1 mB/m. This is a typical result and indicates that the coating quality across the inaccessible highway section is similar to the coating quality along the upstream and downstream sections, where no DCVG indications were observed.

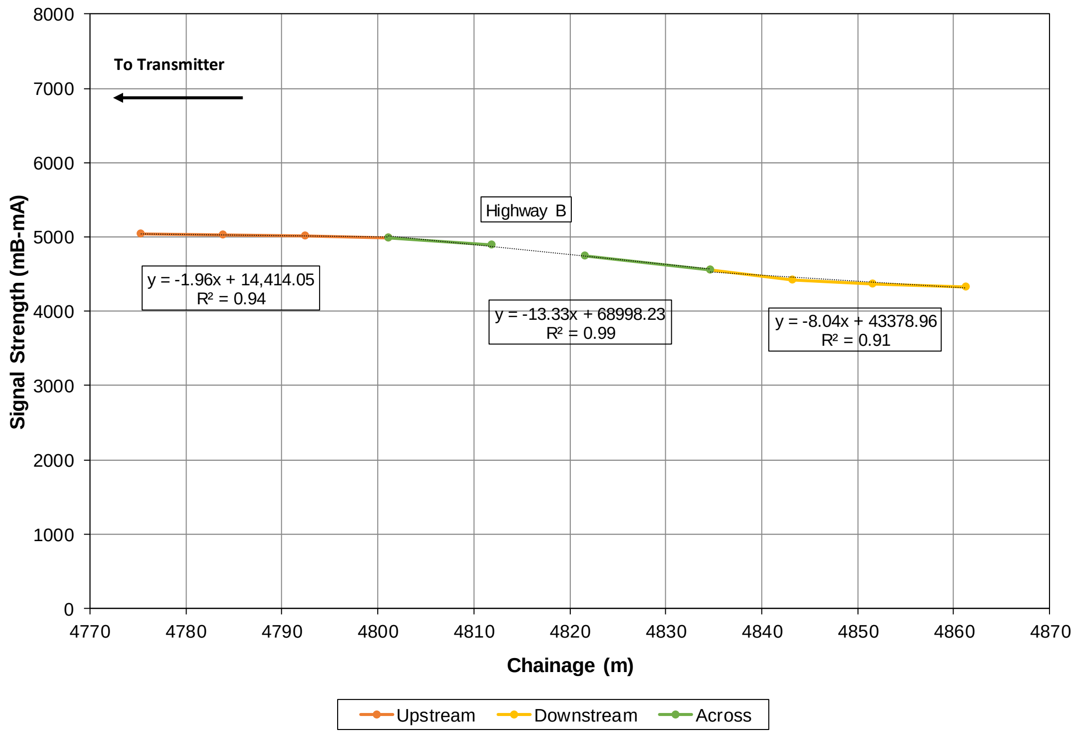

Figure 4: Highway B. AC Current Attenuation Data.

The survey profile at Highway B, however, has significantly higher attenuation across the highway than along the upstream and downstream sections. Notice also that although no coating defects were observed during the DCVG survey in the accessible regions adjacent to the highway, that the ACCA shows some variation in the attenuation even outside the actual inaccessible area. This is consistent with the ACCA being a macro tool and with the manufacturer's data interpretation guidelines.

To evaluate the higher attenuation in terms of severity of indication, a profile was recorded at a known, accessible below threshold (BT) DCVG indication (i.e., 13.3%IR), as shown in Figure 5.

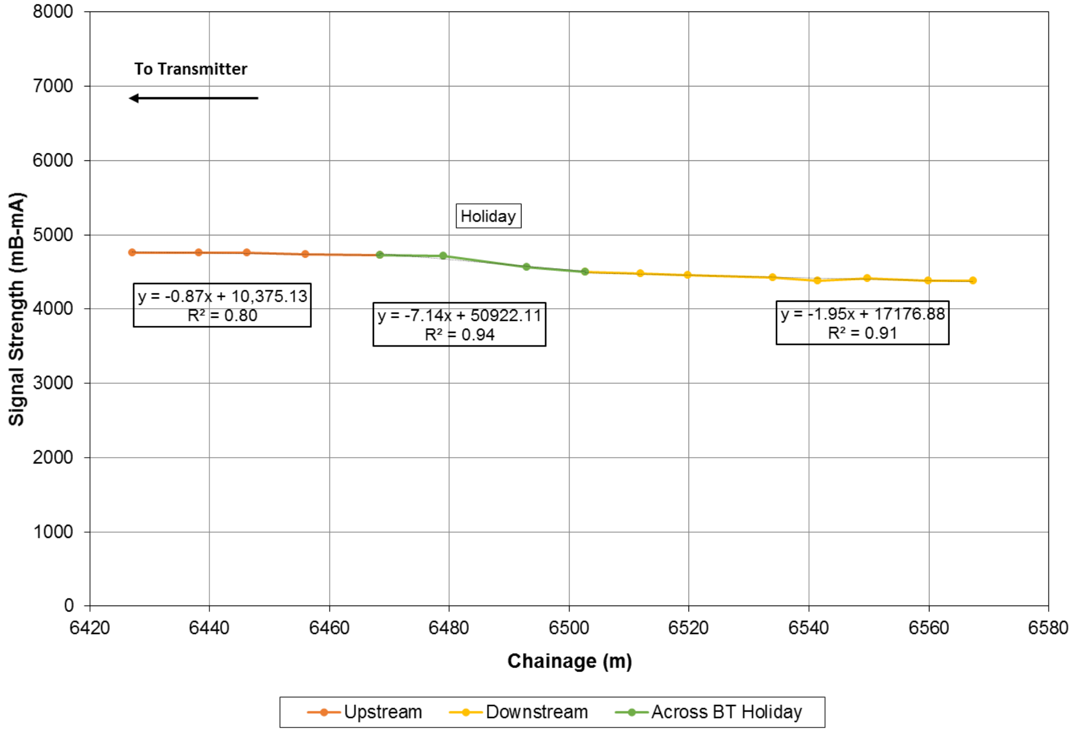

Figure 5: Profile at 13.3%IR BT DCVG Indication for Comparison with ACCA profile.

The survey profile at Highway B is similar, indicating the existence of coating damage, along the inaccessible highway section.

The use of a combined ACCA/DCVG method for assessing the coating quality across areas with limited accessibility could significantly reduce the cost of the ECDA process. In extreme cases, when the area is inaccessible, it could extend the feasibility of the process to include these areas. Furthermore, as more "calibration" ACCA runs would be performed at identified DCVG holidays, it is expected that the added information would allow classifying the indications for prioritization purposes.

CONCLUSIONS

Three cases were presented in this paper dealing with improvements in the use of indirect inspection tools and data interpretation.

In the first case, matching the measured lateral gradient to remote earth to a simulated gradient at the shallow pipe depth (i.e., 0.5 m) and then calculating the gradient produced by the same sized holiday, but with the typical 1.2 m depth allowed adjustment of the %IR for the depth of cover.

In the second case, measuring both the pipe-to-soil potential over the pipe and the gradient at the holiday, eliminated the error introduced by local differences in soil resistivities. A proprietary formula allowed collecting the data in a continuous survey, without having to measure the two parameters to remote earth or interpolating pipe-to-soil potentials measured at adjacent test stations.

In the third case, coating holidays at short sections with limited or no access were identified by using an ACCA survey and comparing the signal attenuation across the section under assessment with the attenuation in adjacent sections, which displayed good coating quality (i.e., no DCVG indications). As more "calibration" ACCA runs would be performed at identified DCVG holidays, it is expected that the added information would allow classifying the indications for prioritization purposes.

REFERENCES

1. NACE Standard TM0109-2009, “Aboveground Survey Techniques for the Evaluation of Underground Pipeline Coating Condition”, Houston, 2007.

2. R. G. Reid, S. M. Segall, R. A. Gummow, “Results from an ECDA Plan”, CORROSION 2005, Paper No. 05184, Houston, TX.

3. S. M. Segall, R. A. Gummow, John Shore, “Ensuring the Accuracy of Indirect Inspection Data in the ECDA Process”, CORROSION 2010, Paper No. 10061, San Antonio, TX.