

RESULTS FROM AN ECDA PLAN

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ABSTRACT

Under an Integrity Management Program (IMP) for natural gas transmission lines, the ECDA concept was analyzed and the process was validated from 2002 to 2004. A Plan was developed and implemented in 2004 on one 17 km pipeline and segments of two other pipelines. This paper covers the Request for Proposal (RFP) methodology, the selection of a service provider, the execution plan and the results obtained.

INTRODUCTION

The pipeline industry has been very active in recent years in the area of pipeline integrity. In the U.S., the 'Liquids Rule' for companies that own or operate 500 or more miles of hazardous liquid pipelines was issued in December 2000, with extension to smaller companies following in January 2002. In November 2001, the API 1160 standard, "Managing System Integrity for Hazardous Liquid Pipelines" was issued. In anticipation of the 'Gas Rule', work began on the development of two industry standards. The ASME/ANSI B31.8S *Managing System Integrity of Gas Pipelines* was published in 2001 and the NACE RP 0502

Recommended Practice for External Corrosion Direct Assessment (ECDA) was approved in 2002. The Pipeline Safety Improvement Act was signed into law by Congress on Dec. 17, 2002. In December 2003 the DOT Office of Pipeline Safety (OPS) amended the *Code of Federal Regulations* (CFR) to establish new requirements for "*Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipelines)*" in section 49 CFR 192, including the incorporation of the ASME/ANSI B31.8S and NACE RP 0502 standards by reference.

In Canada, the National Energy Board (NEB) and most provincial Regulators referenced the Canadian Standards Association Z662 standard for Oil and Gas Pipeline Systems. With the revised Onshore Pipeline Regulations (OPRs) issued in 1999, the NEB moved to less prescriptive, more goal-oriented regulations. This included a requirement for the development of a Pipeline Integrity Management Program (IMP), along with Guidance Notes to provide additional direction to implementing the regulations. These regulations recognized ILI and hydro-static testing as well as specific engineering assessment, but made no reference to ECDA.

In Ontario, Union Gas Ltd. (A DUKE Energy Co.) developed their IMP under the provincial adoption of the section of the OPRs, and associated Guidance Notes, that deal with Pipeline Integrity in the Ontario Regulations. These regulations cover pipelines that operate at or above 30% of the specified minimum yield strength (SMYS). For a variety of reasons, the use of the ECDA was included in the IMP.

BACKGROUND

Union Gas operates in Ontario, Canada, providing natural gas service to the entire province with the general exception of the Toronto, Ottawa and Niagara areas. The company has storage piping (20 reservoirs holding 150 bcf of gas), transmission and compression piping (2800 kms of pipelines and 5 compressor stations with 338,727 bhp), distribution piping (36,180 kms of which 16,462 kms are steel), and service laterals (21,648 kms).

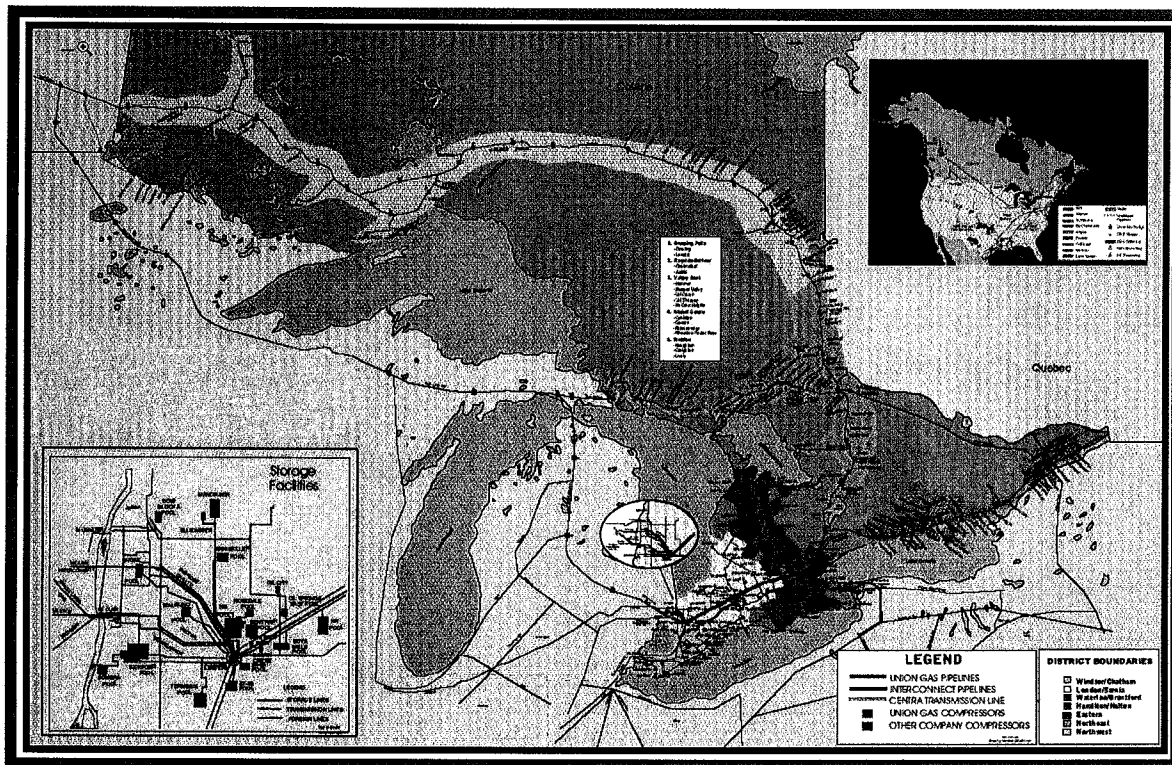


Figure 1. Geographic Location of Union Gas Facilities

While there are no specific timeframes referenced within the OPRs or the Ontario Regulations, the company has committed to complete the baseline condition assessment of the relevant pipelines within a ten year plan, with 2002 being the initial year. The scope is not limited to High Consequence Areas as in the case in the U.S. The ILI tools and the hydro-static testing method were noted in the regulations (OPR), but not ECDA, as a means to complete the condition assessment. Through PRCI and other associations, the company has followed the activities of the 'Gas Rule' and monitored the development of the ECDA process.

In developing its formal IMP for pipelines that operate at or above 30% SMYS, the pipeline operator built on its previous practices to continue to improve and enhance integrity management of its facilities. As part of its enhanced IMP, the company has evolved from using subject matter experts to prioritize the pipelines within the baseline assessment plan in 2002 to using a qualitative risk application that pulls and aligns data from GIS (Geographic Information Systems) and other systems. The output can be viewed at an aggregate pipeline level down to a dynamically segmented section of the pipeline.

As part of the 2002 Integrity Plan a 145 km pipeline was inspected by ILI tools with digs scheduled for 2002/3. Because of the need and intention to incorporate the ECDA process in the integrity program, it was seen as an opportunity to use a portion of this line as a means to validate the ECDA process, an industry active direction, at the time. It should be noted that the now well known NACE RP 0502 was not complete at this point. The first section reviewed for this validation had to be rejected due to the rock shielding, as covered in the RP draft pre-assessment step. A second 10 km section was chosen and ultimately became part of PRCI's

research scope on ECDA validation. The indirect inspection was done in 2002 and the direct examination was completed in 2003. PRCI is to complete their analysis in 2004 with a report due in early 2005.

Based on what the pipeline operator believes is the success of this validation, as well as industry reports elsewhere, there was a selection of pipelines or segments thereof included in the 2004 Integrity plan for ECDA work. ECDA work also includes corrosion rate determination, an aspect that can be utilized not only in ECDA re-inspection interval but other tools as well.

This paper will briefly show the validation project results, as viewed by the company, but will mainly cover the development of the ECDA portion of the integrity program and highlight the 2004 plan, including the line selection, RFP for service provider and the four step process, including results.

ECDA PROCESS PLANNING

As the company developed their documented IMP, a list of pipelines that operated at or above 30% SMYS was generated. This work included assigning names to each unique piece of pipe, including very short stubs, so they could be properly tracked, and aligning all of the attributes for the pipelines within the GIS system to allow for the risk ranking process.

The list of pipelines was categorized into three groups based on the primary method of assessing the condition of the lines. The primary groups included – those that would be ILI inspected, those that would be reviewed by the ECDA process and those that were too short for either process and were therefore to be inspected by ‘bell hole digs’.

The ECDA process for the second group of pipelines was selected for a number of reasons. There were constraints to using the ILI tool, including tool size availability, cost to get the pig ready, dead end or no back feed lines, short lines, etc. Also, the main risk for these lines would be confirmed as external corrosion.

Although some of the analysis was not complete on the validation project, there were excellent direct inspection results. Of the six excavations that were completed, five found exactly what was predicted, or explained. The sixth excavation showed an interference (buried steel corrugated culvert) with the indirect inspection data. Metal loss from the ILI was found under well bonded coating (no ECDA prioritization) and coating loss/damage was also found.

From its positive validation project results and industry developments, the company wanted to further advance the use of ECDA as part of its 2004 Integrity Plan and to learn more about the process and its applicability. In addition to considering the risk assessment results, consideration was given to a group of potential lines from two vastly different geographical areas in the franchise. Northern Ontario has the Canadian Shield, and southern Ontario is mainly farmland. We also wanted to learn more about the Request For Proposal (RFP) process and assess the most appropriate approach to tendering the work. A lump sum approach was selected rather than one based on time and material.

From a scheduling requirement, the site visits for northern Ontario were done in late April. Due to the terrain, it was necessary to use a helicopter. The route was varied and difficult. Ultimately, although we received bona fide RFP submissions for this area, it was decided to drop this portion of the 2004 plan in favor of 'walking before running' or developing our implementation expertise on more friendly ground (literally).

The idea of a lump sum RFP was questioned by several service providers. Concerns covered several items, including:

- How much pre-assessment do they expect (most pre-assessment data was supplied with the RFP);
- What if the close interval potential survey (CIPS) and direct current voltage gradient (DCVG) need to be supported by other tools (these tools were specified in the RFP document along with separate costs for other tools if the service provider identified their need);
- How many digs would be required (used a unit price).
- Perhaps the post assessment seemed remote at RFP time, but there were few questions on this step.

The RFP stated that the pipeline operator would do the excavations but the service provider would complete the data collection. The work had to be in accordance with NACE RP 0502. The service provider was also required to submit a report and prepare a presentation after each step of the ECDA process.

A service provider, Corrosion Services Company Limited (CSCL) was selected to complete the ECDA process on the 17.2 km NPS 8 North Leamington Line, a 4.2 km section of the NPS 16 Panhandle Line, and a 0.24 km section of the NPS 12 North Brantford Line.

PLAN EXECUTION

The pre-assessment was based on the extensive database built over the years by the pipeline operator as part of the risk management plan. The data included strip maps, aerial photos, alignment sheets, line change reports, ILI reports for adjacent sections, maintenance data, cathodic protection survey data and excavation reports on adjacent areas.

The data review confirmed the feasibility of the ECDA on the selected lines and pointed to several factors to be considered in establishing the ECDA regions, selecting the indirect inspection tools and defining the indications and their classification criteria:

- a) Sections of 16" Panhandle line and Leamington North line run in parallel with high voltage power lines, creating a possible risk of AC induced corrosion on well coated piping. As such, a section of the 16" Panhandle line installed in 1983 and coated with extruded polyethylene was defined as a separate ECDA region and AC induced voltages and soil resistivities were recorded at all the test stations. Since the risk of AC induced corrosion increases with the magnitude of the AC current density, which is higher as the size of the holiday decreases, the classification criteria for coating damage were re-evaluated in these sections.

- b) Magnesium anodes directly connected to the pipe were installed in 1999 on the Leamington North line, at the new crossing with Hwy 3. In this case, an alternative criterion for cathodic protection was defined, as true instant-off potentials could not be measured. It was intended to reconnect these anodes via test stations for future assessments.
- c) Brantford Transmission Station Take-Off line is electrically isolated from the Trafalgar lines and could be subject to DC interference, warranting the use of DC interference testing as an indirect inspection tool.

Four ECDA regions were defined on the 16" Panhandle line and Leamington North line, with the cased crossing at Manning Road on the Panhandle line selected as a separate region. For the purpose of this direct assessment, the two Leamington North lines (i.e. 8"/10" Leamington North line and the 8" Leamington North – Windsor Line Tie Over), which operated until 1970 as one line, were considered as one segment (i.e. Windsor Valve Station – Comber Station – Leamington North Gate Station).

Roads and creek crossings were defined as separate ECDA regions, since they might require the use of alternative indirect inspection tools (i.e. AC attenuation survey instead of DCVG survey). The short (i.e. 0.24 km) Brantford Transmission Station Take-Off was defined as one ECDA region. The ECDA regions are summarized in Table 1 and Figures 2 to 4.

Table 1. ECDA Regions and Characteristics

Pipeline	ECDA Region	Total Length (m)	Characteristics
16" Panhandle	#1	1690	Extruded Polyethylene Coating. Regular ROW. Risk of AC Corrosion
	#2	2445	Wax Coating. 1951 Pipe. Regular ROW
	#3	101	Road/Creek Crossings
	#4	26	Road Crossing with Casing (Manning Road)
8"/10" Leamington North	#1	410 (2x205)	Coal Tar Enamel Coating. Regular ROW. Multiple Lines. HV Powerlines Corridor
	#2	16491	Coal Tar Enamel Coating. Regular ROW
	#3	227	Coal Tar Enamel Coating. Road Crossings
	#4	99	Extruded Polyethylene Coating. Hwy 3 Crossing
12" Brantford Transmission Station Take-Off	#1	244	Coal Tar Enamel Coating. Multiple Lines. Risk of DC Interference

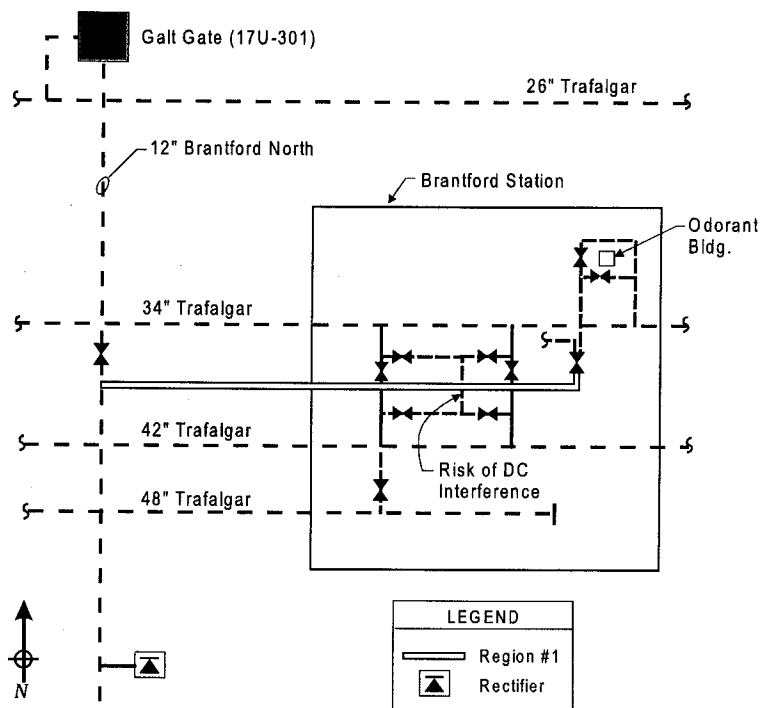


Figure 2. 12" Brantford Transmission Station Take-Off

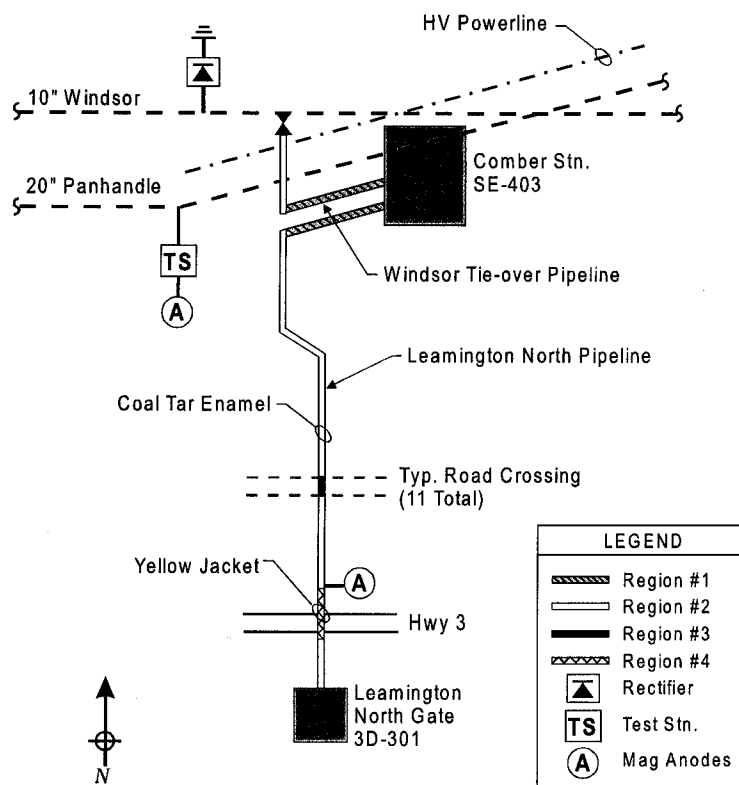


Figure 3. 8"/10" Leamington North Lines

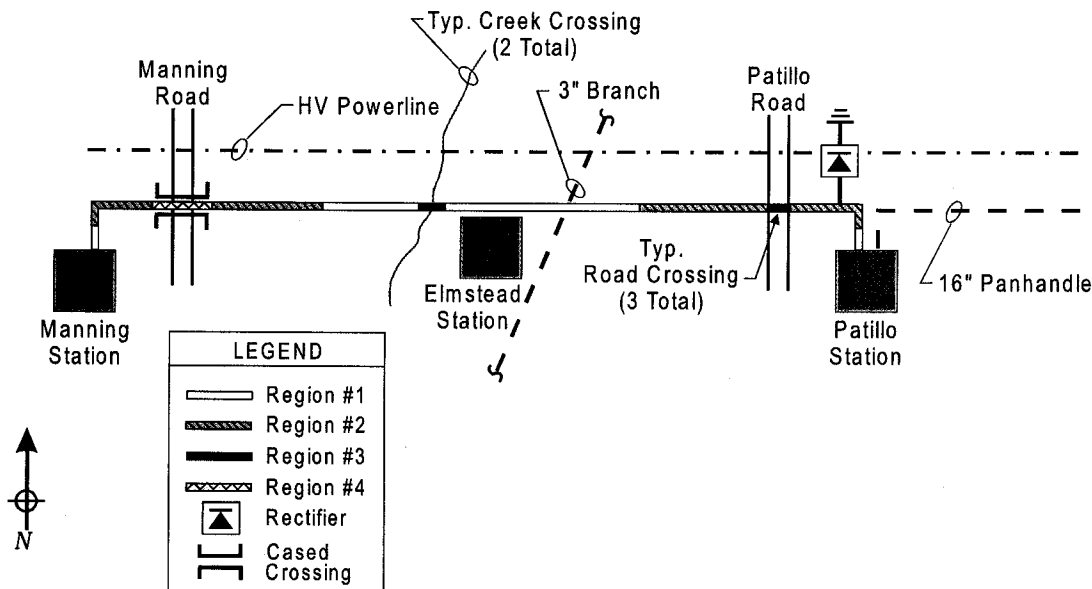


Figure 4. 16" Panhandle Line: Patillo Station – Manning Station

An integrated CIPS/DCVG survey was selected to merge the two main indirect inspection tools for the project. The close interval potential survey (CIPS) and the DC voltage gradient (DCVG) survey were conducted simultaneously, with both the pipe-to-soil potential and the 3m lateral gradient recorded at each location with the CP current cyclically interrupted. Provision was made to use an AC attenuation survey as an alternative tool, if the DCVG could not be applied due to high contact resistance or intense telluric activity. Additional indirect inspection tools selected for the project included interference testing and AC induced voltage and soil resistivity measurements.

With no indirect tools to assess cased piping (Panhandle Line, Region #4), testing for a pipe-to-casing short was performed.

During the integrated CIPS/DCVG survey, potential waveforms were recorded to confirm that all influencing rectifiers were interrupted.

A frequency analysis was conducted on potential waveforms recorded during the OFF cycle to identify 120 Hz signatures of influencing single phase rectifiers left ON or out of synchronization. This ensured that there was no residual DC current from single phase rectifiers influencing the pipeline during the OFF cycle. Note that the signature of three-phase rectifiers cannot be accurately detected as it coincides with harmonics of the 60 Hz AC induced voltages.

Data loggers were installed up-stream and down-stream of each surveyed section to record the telluric activity. Moderate activity was recorded on July 12 and July 13 on the Leamington North line (see Figure 5) and the integrated survey results were subsequently tellurically compensated.

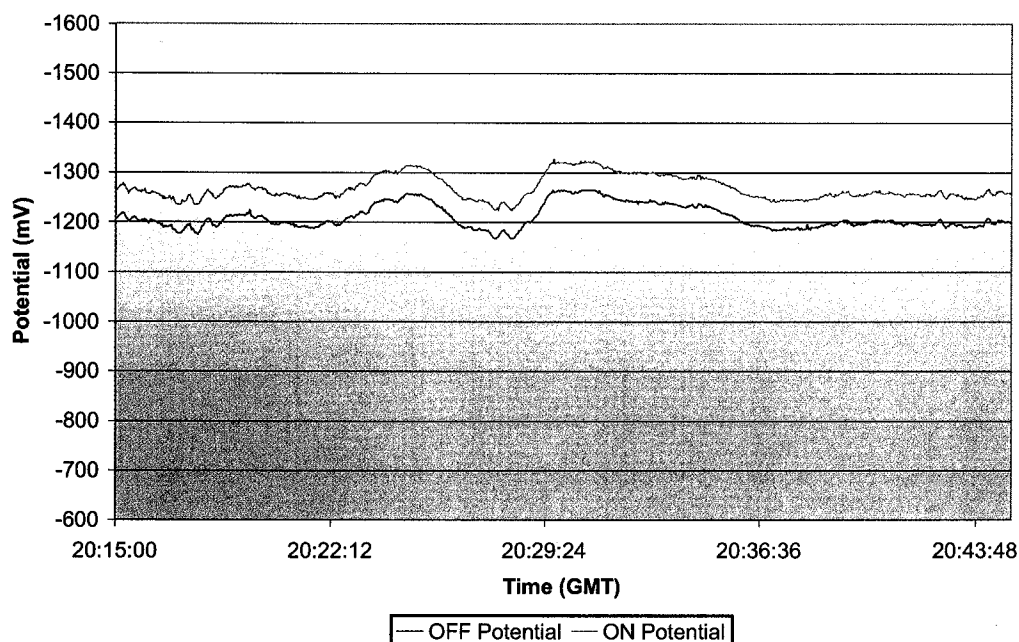


Figure 5. July 12. 8" Leamington Line. TP 7. Telluric Activity (30 Minute Sample)

The identification and classification criteria for indications were developed considering both the generally accepted criteria for protection level, severity of coating defects, AC induced corrosion and DC interference, as well as the interaction between indications in terms of corrosion risk for the pipeline. For example, a category 1 coating defect (less than 15% I-R) which is normally considered of low importance with no repair required, was classified as a minor indication, except when a moderate or severe AC corrosion risk is identified at the same location. In this case the DCVG indication would be re-classified as severe and subsequently the area would be defined as "Immediate Action Required".

The classification criteria for indications are summarized in Table 2.

Table 2. Classification of Indications

Survey Type	Indication		
	Minor	Moderate	Severe
Close Interval Survey (CIPS)	V_{OFF} more positive than -850 mV _{CSE} or V_{ON} more positive than -1000 mV _{CSE} ^[1]	V_{OFF} more positive than -800 mV _{CSE} or V_{ON} more positive than -900 mV _{CSE} ^[1]	V_{OFF} more positive than -750 mV _{CSE} or V_{ON} more positive than -800 mV _{CSE} ^[1]
AC Induced Corrosion	AC current density from 20 A/m ² to 50 A/m ²	AC current density from 50 A/m ² to 100 A/m ²	AC current density >100A/m ²
DCVG with Minor or No AC Induced Corrosion Indications	%I-R from 2.5% to 35% and C-C behavior	%I-R from 35% to 60%, C-C or C-N behavior	%I-R > 60% or C-A or A-A behaviour
DCVG with Moderate or Severe AC Induced Corrosion Indications	%I-R from 15% to 35% and C-C behavior	%I-R from 35% to 60% C-C or C-N behavior	%I-R from 2.5% to 15% or %I-R > 60% or C-A or A-A behaviour
DC Interference with no CIPS indication (line fully protected)	Electropositive shift ^[2] >30 mV	N/A	N/A
DC Interference with no CIPS indication (line fully protected)	Electropositive shift ^[2] <30 mV	Electronegative shift* from 30 mV to 60 mV	Electronegative shift* >60 mV

^[1] measured influencing rectifiers OFF with galvanic anodes connected.

^[2] measured when the offending rectifier is turned ON.

Note that fully protected locations susceptible to DC interference were classified as minor indications, since they might be subject to corrosion during outages of their CP system.

The areas identified for direct inspection were defined based on the prioritization criteria recommended in NACE Standard RP0502-2002. When no indications classified as “Immediate Action Required” or “Schedule Action Required” were found, a minimum of four direct examinations (two as per Section 5.10.1 and two as per Section 6.4 of NACE Standard RP0502-2002) at three excavation sites were typically scheduled. The control examination at an area where no indication was detected was performed by extending a randomly selected previous excavation site. However, the short 12” Brantford Transmission Station take-off displayed only one indication and subsequently the minimum number of excavations, including “control” was set at two.

Additional excavations were performed within the allowed budget to provide more data for validation of the ECDA approach.

With no indications classified as “Scheduled Action Required”, the minimum number of excavations required by NACE Standard RP0502-2002 does not depend on the number of ECDA regions selected during the pre-assessment stage of the ECDA.

RESULTS

16” Panhandle Line

Typical results of the integrated CIPS/DCVG survey on the Panhandle line are plotted in Figure 6. Pipe-to-soil potentials are plotted on the left-hand ordinate axis and the lateral gradient voltages are plotted on the right-hand ordinate axis.

The $-850 \text{ mV}_{\text{CSE}}$ criterion is also shown in the chart to identify CIPS indications. The line was fully protected along the entire section under assessment, since the proximity of the rectifier ensured that sufficient current was available to protect moderate or even large holidays.

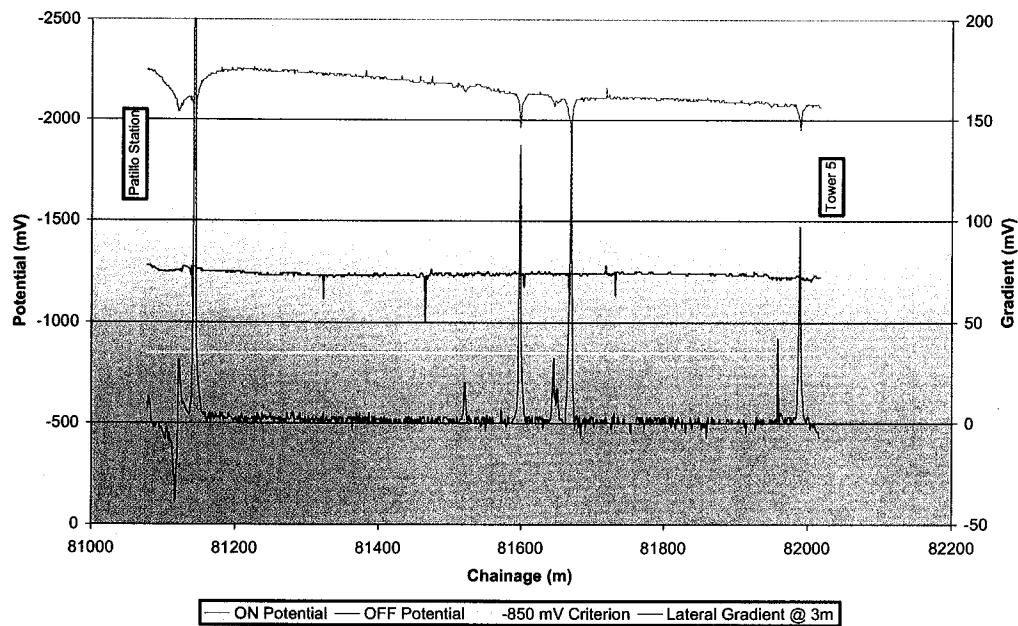


Figure 6. 16" Panhandle Line. CIPS/DCVG Survey (1.1 Km Sample)

DCVG indications were identified by the characteristic shape of the lateral gradient (i.e. increasing, reaching a maximum value at the epicenter of the holiday and then decreasing), as shown in Figure 7.

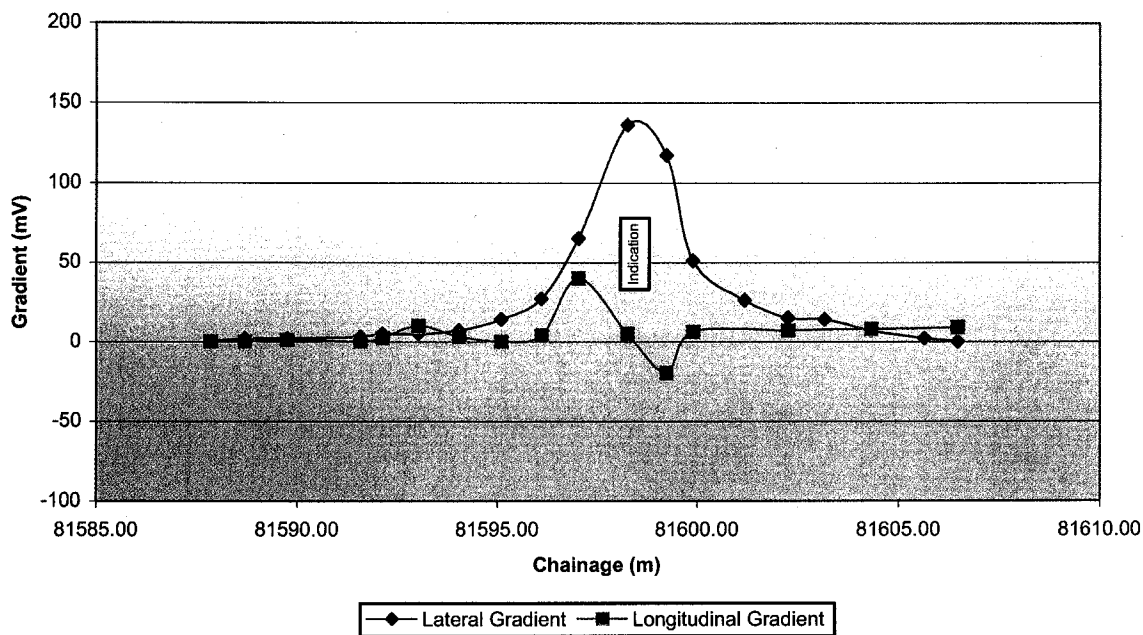


Figure 7. 16" Panhandle Line. Chainage 81598m. Voltage Gradients at DCVG Indication

For reference, the longitudinal gradient was estimated from the CIPS data and displays a different indication signature (i.e. increasing, reaching a maximum, changing sign to reach a

minimum and returning to zero, with the epicenter at the null point between the maximum and minimum value). Note that the indications appear clearly defined in the relatively uniform, low resistivity clay soil. The % IR severity was calculated based on the recorded values of the pipe-to-soil potential and 3m lateral gradient. A total of 44 DCVG indications were identified along the section, as shown in Figure 8.

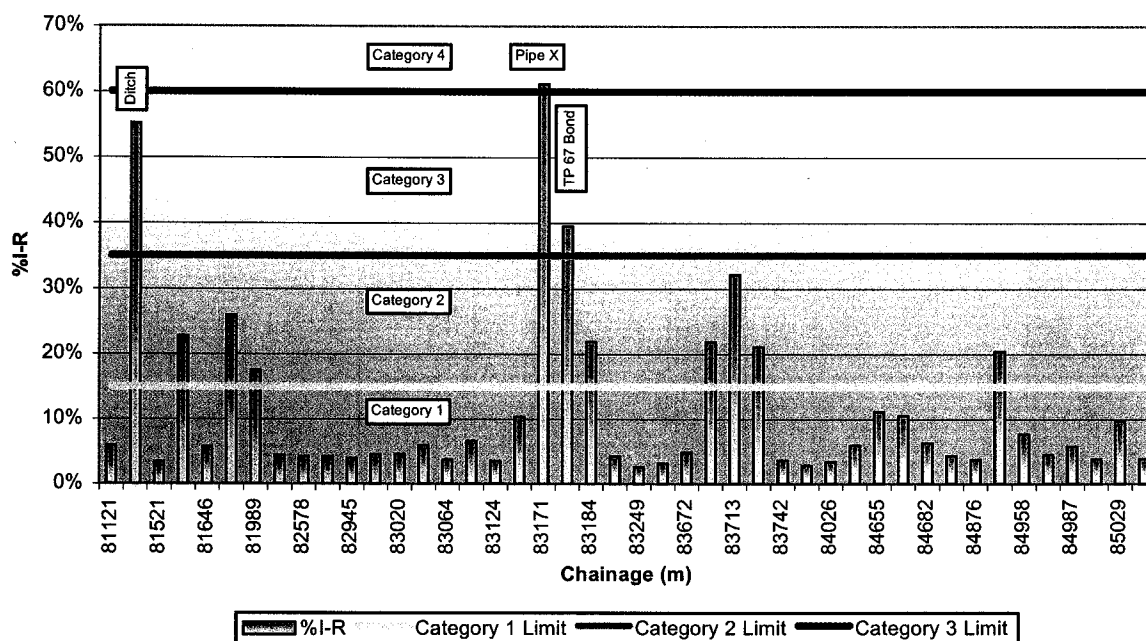


Figure 8. 16" Panhandle Line. Summary of DCVG Indications

A Category 3 indication was found at the ditch crossing, west of Patillo Road (chainage 81143.25m). This severity index (55.2%) can be attributed in part to the gradient distortion produced by the reduced soil cover. Considering the difficulties associated with excavating the pipe versus the probability of mechanical damage and the risk of corrosion due to the possible presence of de-icing salt in the case of a rectifier outage, it was essential to re-assess the severity of the coating damage indication under reduced cover.

The measured gradient to remote earth (orange line) was matched to a simulated gradient produced by a 50 cm² holiday with a 0.5m cover (blue line), as shown in Figure 9.

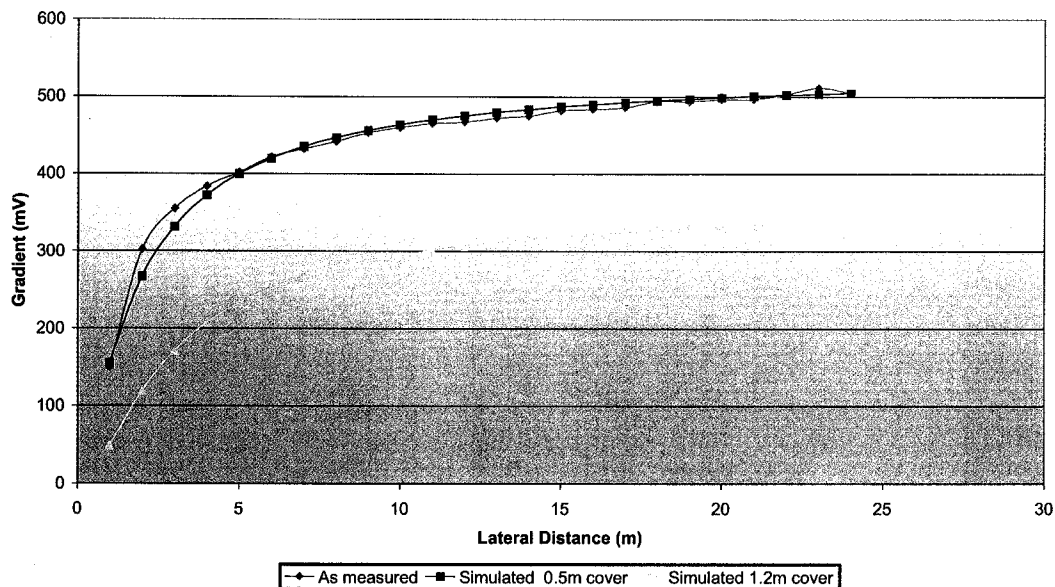


Figure 9. Influence of Reduced Cover on the Severity of Coating Defect

The gradient produced by the sized holiday but with 1.2 m cover was then calculated and plotted (gold line). The reduction in cover results in an increase of approximately 48% (160 mV) in the lateral gradient at 3m. As such, the calculations indicate that the %I-R index at chainage 81143.25m under normal cover conditions would be approximately 40%, instead of 55.2%, still leaving the site as a Category 3 indication.

The severe and moderate indications at chainage 83171.29m and 83171.43m respectively appeared to be related to the gradient produced by the special configuration of Elmstead Gate Station piping. The previous station take off riser was capped off 0.6 m from the new take-off connection. The new 5cm (2") dia. take-off pipe runs for 12.4 m in parallel with the main line and displays three 90° bends before rising above grade inside the station. The cathodically protected 7.5cm (3") dia. branch is bonded at TP67 to the Panhandle line. Considering all these gradient distortions and the fact that the line is fully protected at this location (i.e. $V_{OFF} = -1250 \text{ mV}_{CSE}$), no threat to pipeline integrity was anticipated. Furthermore, should a failure shut down the Patillo rectifier, partial protection would be provided from the branch via the bond at TP 67.

The AC induced voltages measured at the test stations in conjunction with soil resistivity measurements resulted in AC current densities of less than 20 A/m^2 , showing no risk of AC induced corrosion along the entire section under assessment. The results were confirmed by a 24 hour chart recording at TP 68.

No short was found between pipe and casing at the Manning Road crossing.

Of the 44 indications found on the Panhandle line, 41 were classified as minor, 1 as moderate, and 2 indications were attributed to gradient distortion.

All the locations were defined as "Suitable for Monitoring" according to the prioritization criteria recommended in Paragraph 5.2 of the NACE Standard RP0502-2002. The only location which met the criterion for "Scheduled Action Required" with one category 4 (severe) and one

category 3 (moderate) indications in close proximity at chainage 83171m was downgraded to “Suitable for Monitoring” as they were related to the gradient produced by the special configuration of Elmstead Gate Station piping.

Direct examinations were conducted at four locations displaying %I-R higher than 20%. The results are summarized in Table 3.

Table 3. 16” Panhandle Line Results of the Direct Examinations

Chainage (m)	Indications			Direct Examination Results			
	DCVG	CIPS	AC Corrosion	Coating Damage	Corrosion Attack	Calcareous Deposits	Trapped Water pH
83712	Minor (32.1% C-C)	-	-	Yes	Superficial brown staining	Yes	10-11
83701	Minor (21.1% C-C)	-	-	Yes	Superficial brown staining	Yes	11
83727	Minor (21.9% C-C)	-	-	Yes	Superficial brown staining	Yes	11
84944	Minor (20.4% C-C)	-	-	Yes	None	Yes	11-12
84972 (Control)	-	-	-	None	None	No	No

Coating damage was found at all the four excavated locations. The holidays were covered by hard lumps made of a mix of clay and calcareous deposit as shown in Figure 10. (site A at chainage 83712m). No corrosion pits were found after removing the deposit and the pH of the trapped water was between 10 and 12. The exact size of the holiday could not be exactly measured, as the wax coating cracked during the removal of the hard calcareous deposit – clay mix. The coating inspection map for this site is shown in Figure 11.

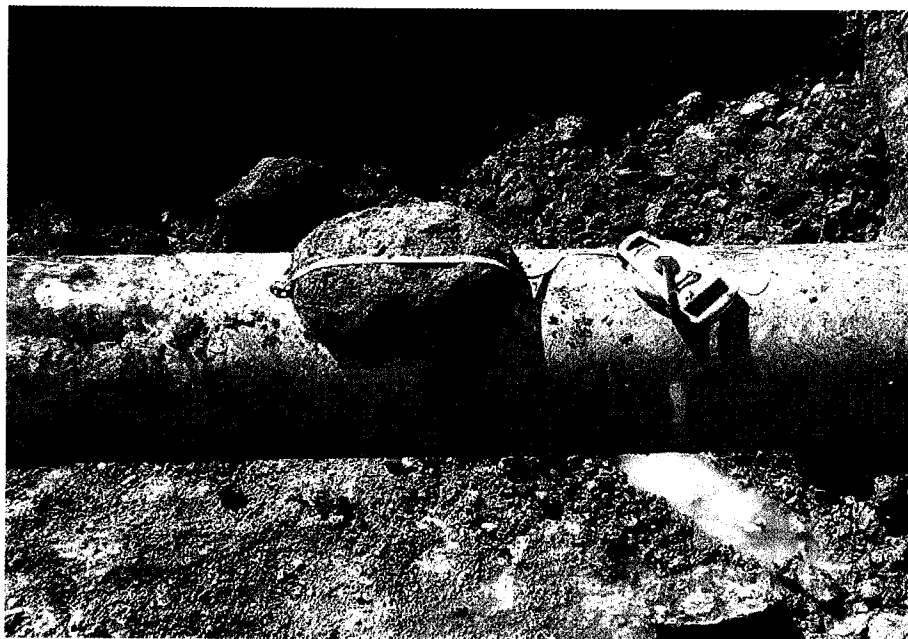


Figure 10. 16" Panhandle Line. Clay-Calcareous Deposit Lump at Site A (chainage 83712m)

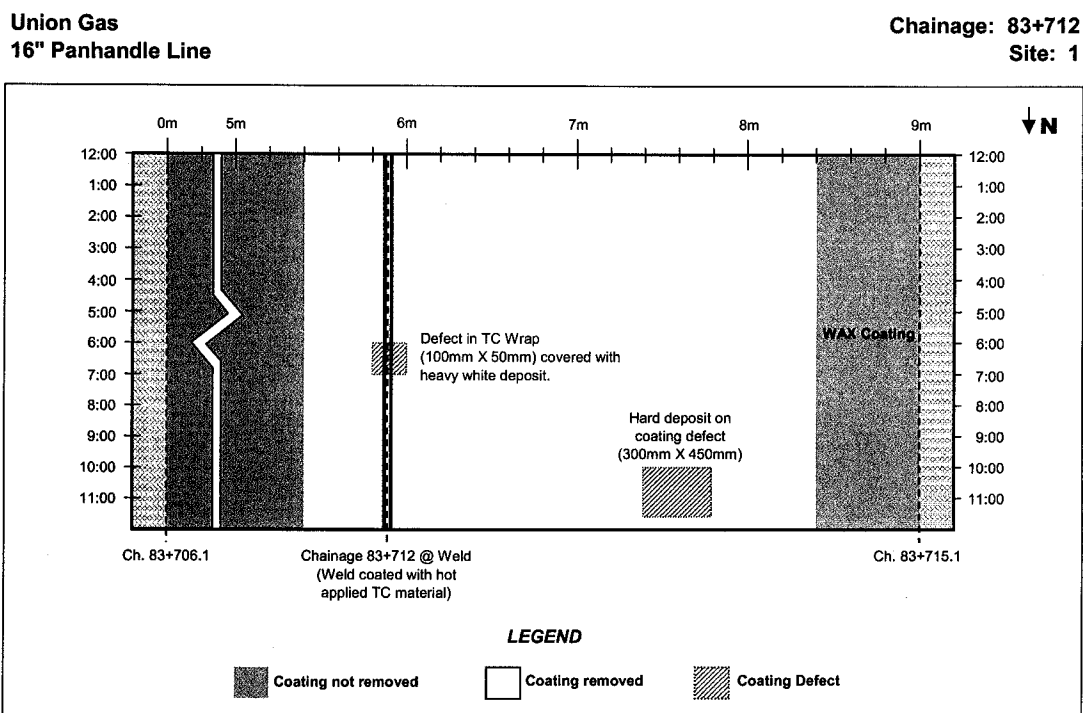


Figure 11. 16" Panhandle Line. Ch. 83712. Coating Inspection Map

A control dig was performed at Site E (chainage 84972m) and no damage to the pipe coating was found. A small section of coating was removed and no signs of corrosion were found on the exposed pipe. Additional excavations are being considered for Spring 2005.

Based on the results of the indirect inspections, the pre-assessment information and the data obtained from the direct examinations performed until now, it was concluded that the risk of external corrosion was negligible and the re-assessment interval will be determined based on further analysis.

8"/10" Leamington North Lines

The results of the integrated CIPS/DCVG survey conducted on July 12, 2004 were telluric compensated. The "As Measured" and compensated data are plotted in Figures 12 and 13.

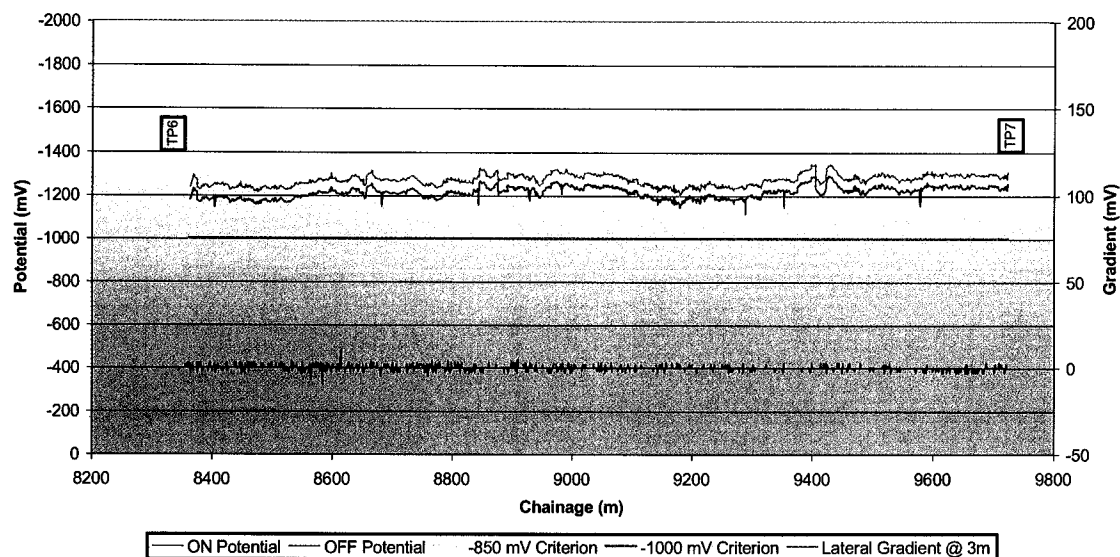


Figure 12. 8" Leamington North Line. CIPS/DCVG Survey Sample (As Measured)

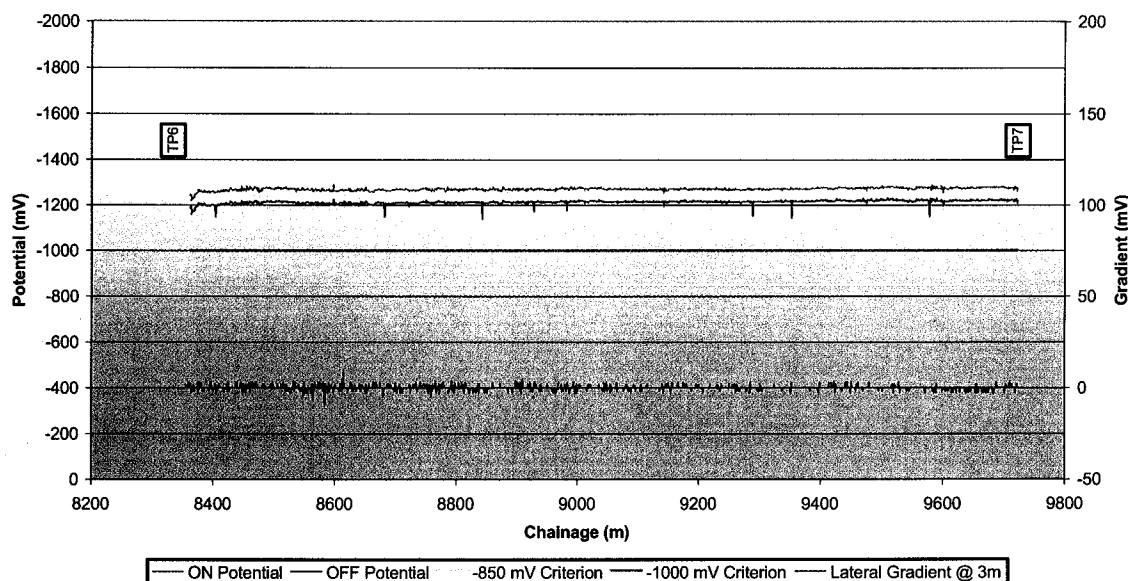


Figure 13. 8" Leamington North Line. CIPS/DCVG Survey Sample (Compensated)

The extreme soil dryness made the survey very difficult, as poor contact resulted in anomalous gradient readings. At some locations, the gradient was re-measured several times, until the crew was satisfied that the recorded potentials were accurate.

The results of the CIPS survey indicated that the line was fully protected along its entire length.

The AC induced voltages measured at test posts TP5 and TP6 (chainage 5570.36m and chainage 8349.90m) were 2.2V and 3.7V, respectively. At low soil resistivities (i.e. less than 2100 Ω -cm), the calculated AC current density on a 1 cm² holiday exceeded 20 A/m² but remained less than 50 A/m². As such, small holidays in this area qualified as AC induced corrosion minor indications.

Seventeen DCVG indications were found along the line, as shown in Figure 14.

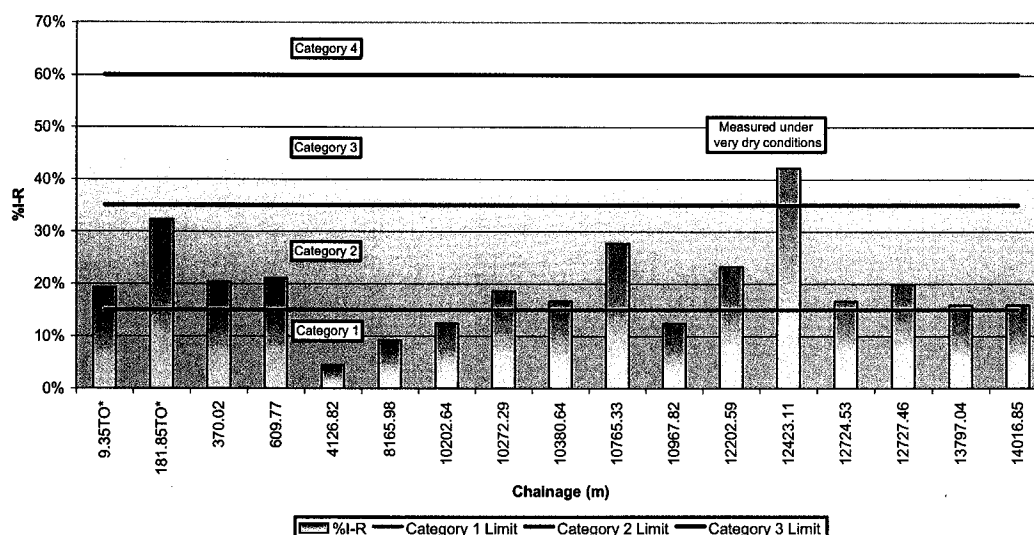


Figure 14. 8"/10" Leamington North Lines. Summary of DCVG Indications

All the coating defects were classified as minor, except for one moderate (42.2% Category 3) indication at chainage 12423.11m, which was attributed to the extremely dry soil conditions.

All the locations were prioritized as "Suitable for Monitoring". Two areas were specifically recommended for excavation. The first location at chainage 181.85m on Leamington North – Windsor Line tie-over pipeline displayed 32.2% %I-R, measured under ideal conditions and the second one at chainage 8165.98m on Leamington North line displayed a small holiday (i.e. 9.2% I-R) in conjunction with a minor risk of AC induced corrosion.

Direct examinations were conducted at seven locations displaying indications and at one control location. The results are summarized in Table 6. Coating damage was found at all the seven excavated locations, which displayed DCVG indications.

Table 6. Leamington North. Results of the Direct Examinations

Chainage (m)	Indications			Direct Examination Results			
	DCVG	CIPS	AC Corrosion	Coating Damage	Corrosion Attack	Calcareous Deposits	Trapped Water pH
0+181.85 tie-over	Minor (32.2% C-C)	-	-	3 large scars (30 cm each)	No active corrosion Mechanical Damage	Yes	No trapped water
8+165.98	Minor (9.2% C-C)	-	Minor 39 A/m ²	Small impressions	None	Yes	11
12+423.11	Moderate* (42.2% C-C)	-	-	Minor holidays & superficial scratch	Minor staining	-	No trapped water
10+765.33	Minor* (27.7% C-C)	-	-	Minor holidays and 1 coating sag	Minor staining	Light	No trapped water
12+202.59	Minor* (23.2% C-C)	-	-	Small impressions	Minor staining	Light	11-12
12+724.53	Minor (16.6%)	-	-	Minor holidays	Minor staining	-	11
12+727.46	Minor* (19.8)	-	-	Minor holiday	Minor staining	-	11
8+162 Control	-	-	-	None	None	N/A	N/A

* Measured under very dry conditions

At chainage 181.85m on Leamington North – Windsor Line tie-over, three large scratches attributed to third party damage were found in the coating (see Figure 15). The pipe was slightly gouged to depths up to 0.36mm. No active corrosion was observed. The gouges were buffed out after being evaluated and considered no threat to pipe integrity.



Figure 15. Leamington North Tie Over. Coating Damage at Chainage 181.85m

A control dig was performed at chainage 8162m and no damage to the pipe coating was found. Based on the results of the indirect inspections, correlated with the pre-assessment data and validated by the eight direct examinations, the corrosion rate is considered as negligible and the re-assessment interval will be determined based on further analysis.

12" Brantford Transmission Station Take-Off

The results of the CIPS/DCVG survey are shown in Figure 16 and the results of the DC interference testing are plotted in Figure 17.

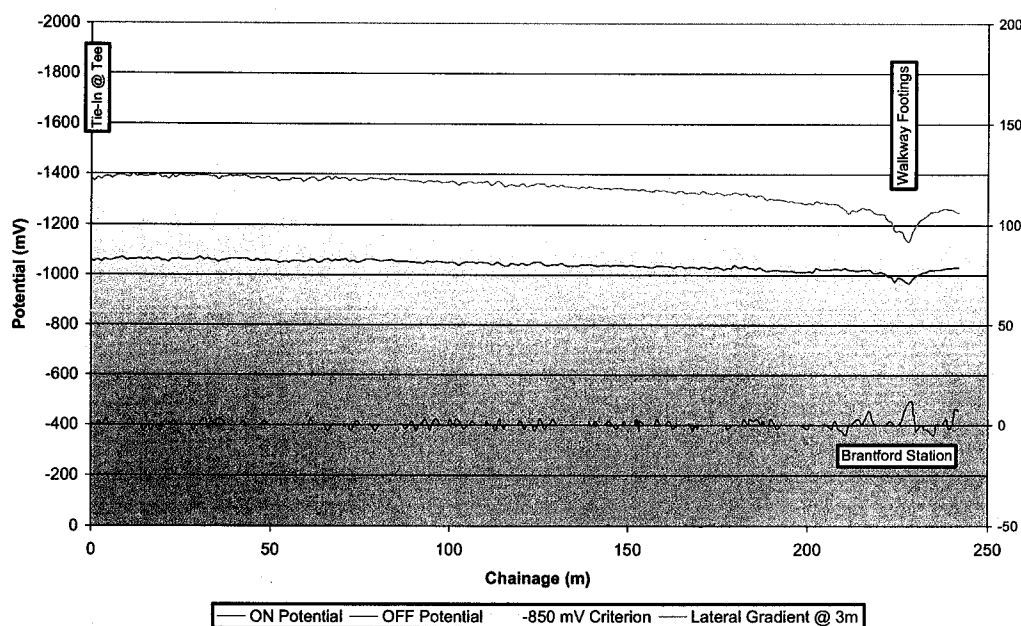


Figure 16. Brantford Transmission Station Take-Off. CIPS/DCVG Survey

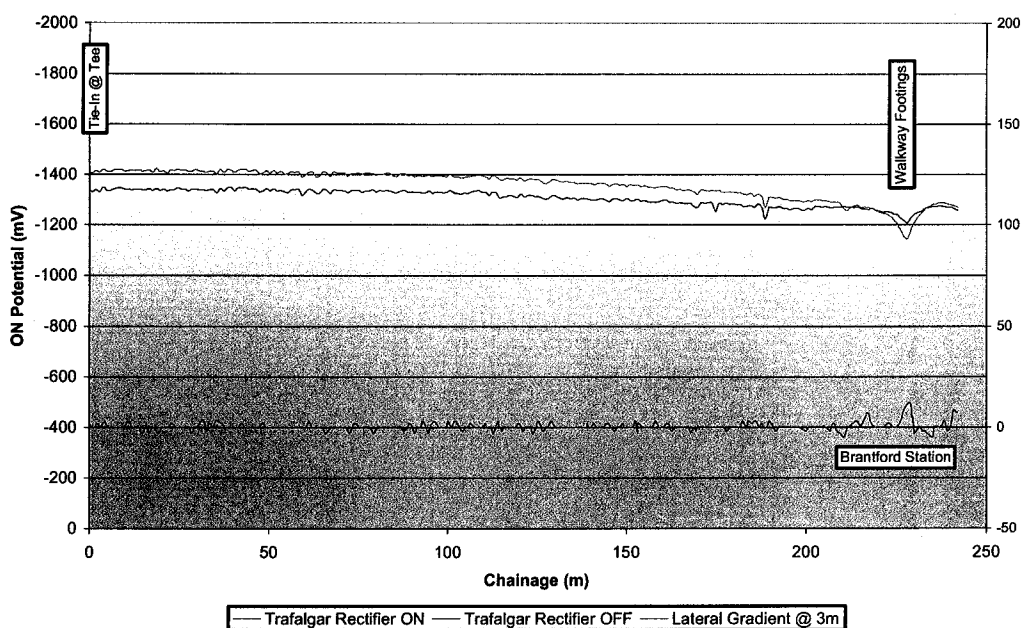


Figure 17. Brantford Transmission Station Take-Off. DC Interference Survey

The pipeline is fully protected along its entire length. A minor DC interference indication was found at chainage 228.92m, near the walkway footings. A possible minor DCVG indication (1.9% I-R C-C) was identified at the same location, however since the line is shorted to the station ground it is possible that the walkway footings are the source of the gradient distortion. The area was defined as "Suitable for Monitoring" and a direct examination will be conducted at this location.

A control dig was performed at chainage 0m, as part of line reconfiguration and no damage to the pipe coating was found.

CONCLUSIONS

The positive results of the ECDA process validation against the ILI tool were instrumental in the pipeline operator proceeding with the ECDA process in their 2004 Integrity Plan.

The ECDA process was performed on more than 21 km of pipeline in southern Ontario. The integrated CIPS/DCVG survey proved to be an accurate tool in locating and aligning indications. When conducting the DCVG survey in very dry soils special attention is required in order to obtain accurate data. False indications were typically eliminated by evaluating the shape of the lateral gradient profile (i.e. increasing, reaching a maximum value and finally decreasing). Additional improvements in data processing, such as deriving the longitudinal gradient profile from the CIPS data and using it in conjunction with the measured lateral gradient to validate indications would be implemented in future surveys. Telluric activity was detected on the well-coated Leamington North line and the data required telluric compensation. As such, the installation of data loggers at remote test stations proved to be justified.

A total of 64 indications were identified, with the vast majority being minor DCVG anomalies. Classification criteria were introduced for correlating indications provided by different indirect inspection tools. For example: DCVG indications with 2.5% to 15% I-R (Category 1) were defined as minor when associated with minor or no AC induced corrosion indications, but were considered severe in conjunction with moderate or severe risk of AC induced corrosion.

All the areas displaying indications were defined as "Suitable for Monitoring". A total of 11 excavations were performed at these areas and all the indications were validated. Three controls digs were performed and no coating damage and/or corrosion activity were found.

Although final reports are in progress at time of writing this paper, the pipeline operator concludes that the ECDA process adequately and accurately evaluated the impact of external corrosion, and to some degree third party damage, on the integrity of pipelines.

The awarding of the work through an RFP, on a lump sum basis was also a success. It does create more 'up-front' work on the part of the pipeline owner but doing this work also gave indirect benefits to the operator (condition of records, involvement of local personnel, etc.).