uniongas
A Spectra Energy Company

April 15, 2016

BY RESS & Courier

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
2300 Yonge Street, 27th Floor
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: Union Gas Limited ("Union")
Leamington Expansion Project
EB-2016-0013

Enclosed please find Union's Reply Evidence for the above-noted project.

In the event that you have any questions on the above or would like to discuss in more detail, please do not hesitate to contact me.

Yours truly,

[original signed by]

W.T. (Bill) Wachsmuth, RPF
Senior Administrator, Regulatory Projects
:sb
Attach.

cc: L. Gluck
M. Millar
All Intervenors

REPLY EVIDENCE OF UNION GAS

Prefiled Evidence

Schedule 1 -	Photograph that shows the western edge of the Abandoned Railway Corridor
Schedule 2 -	Email from the Municipality of Leamington
Schedule 3 -	April 1, 2016 Minutes of Meeting
Schedule 4 -	AC Interference Study for Existing NPS 8 Pipeline
Schedule 5 -	Letter from Corrosion Service Company Limited dated April 14, 2016
Schedule 6 -	Updated Interrogatory Responses to Board Staff 3

INTRODUCTION

1. Union Gas Limited ("Union") provides this reply evidence in accordance with Procedural Order No. 3 dated April 8, 2016.

2. The evidence replies to the material filed by Hydro One Networks Inc. ("HONI") on April 12, 2016. It also updates certain of Union's pre-filed evidence and answers to interrogatories previously filed in this proceeding.

3. The balance of this evidence is organized as follows:

- Preferred route: We discuss Union's practice in arriving at a preferred route for a pipeline and how that practice was followed in relation to the Leamington line at issue in this case.
- Consultation with HONI: We discuss our consultation meetings with HONI and Union's understanding of HONI's position as it evolved over time.
- Engineering Consultant: We discuss Union's retainer of Corrosion Service Company Limited ("Corrosion Service"), a professional engineering firm with special expertise in developing mitigation strategies to permit the close location of pipeline and transmission facilities.
- Evidence and interrogatory update: We update certain of Union's pre-filed evidence and answers to interrogatories.

PREFERRED ROUTE

4. Union followed its standard practice to determine the detailed location of the proposed facilities in the Abandoned Rail Corridor ("corridor") which was identified as the preferred location for the proposed pipeline in the Environmental Report.

5. Union reviewed the site conditions along the corridor, completed a preliminary engineering study, and met with the Municipality of Leamington which owns the corridor. After several meetings with the Municipality, it was agreed between the parties that the location of the pipeline would be best situated east of the waterline along the gravelled portion of the corridor.

6. Union constructed Phase 1 of the Leamington project in 2013. That project was constructed adjacent to the western edge of the corridor. The reason for the difference in this case is the significant change in topography south of County Road 14 (the demarcation of Phase 1 and 2). Specifically, the topography along the edge of the corridor is significantly different north and south of County Road 14. In the area south of County Road 14 the trail is more elevated and there are drainage ditches along the edges of the corridor.

7. Schedule 1 is a photograph that shows the western edge of the trail and the property line between the corridor and the adjacent private properties. If the pipeline were constructed in this location, i.e., one meter off the western property boundary, it would result in:

- the pipeline being constructed under the drainage ditch;
- additional land rights being required from the adjacent property owners;
- construction needing to be completed on agricultural lands;

- the re-location of local drainage networks;
- additional environmental impacts; and
- additional notice being provided to landowners on the western edge of the corridor who were not previously affected and therefore not provided with notice.

8. As a result, Union estimates that there would be an increase in the project costs by over $1.5M and that Union would not be able to meet a 2016 in-service date for customers. Construction would be delayed until 2017 at the earliest. Union would also have to re-open the environmental assessment process to assess new alternatives including road allowances and private easements.

9. Schedule 7 of the HONI Intervenor evidence contains a number of e-mails from the 2014 time frame. At that time, it was not known when or if additional looping would be required for the Leamington system. Any commentary regarding the possible future location of the pipeline would have been made without the benefit of any field work or discussions with the Municipality. Certainly, if the topography did not vary significantly south of County Road 14, Union would very likely have maintained the running line along the western edge of the corridor.

10. As set out above, if Union were to move to the western edge of the corridor as suggested by HONI at page 10, of its evidence there would be a delay to the contracted for November 2016 in-service date.

CONSULTATION WITH HONI

11. Union's standard practice is to work with the landowner to determine the preferred location of the facilities on their land before dealing with encumbrances and potential encumbrances.

12. It is also Union's practice to maximize the practical separation and conduct an engineering analysis to determine the safe separation between a pipeline and a hydro tower. Based on past experience, engineering solutions are available to mitigate the AC interference that may result between a pipeline and a hydro tower.

13. Towards the end of 2015 Union agreed to a running line with the Municipality, Union was, at that time, then in a position to meet with HONI.

14. Union first met with HONI and the Municipality on February 25, 2016. This meeting is discussed in detail in Union's response to HONI 4(f).

> *The February 25, 2016 meeting was attended by Engineering, Project Management, and Lands personnel from Union Gas and Hydro One. The meeting was also attended by staff from the Municipality. During the technical review, environmental and maintenance concerns were identified in relation to Hydro One's proposed tower locations along the easterly limit of the railway corridor. Hydro One's proposed towers are in direct conflict with a drainage ditch. A mutually agreeable solution was reached between Union, Hydro One and Leamington. Hydro One indicated that they were*

starting the process of acquiring land rights. Hydro One estimated an additional 6 meters of easement would be required from the private land owners on the east side of the abandon railway corridor to accommodate moving the tower bases out of the drainage ditch. By moving the tower bases out of the drainage ditch, Union and Hydro One can obtain the recommended 10 meter separation between Union and Hydro One's proposed infrastructure. Hydro One identified that additional land would be required from six land owners which Hydro One is already acquiring land from, on the east side of the rail corridor to implement this solution. The solution also alleviates the need for Hydro One to pursue land rights from six land owners on the west side of the rail corridor.

15. At the February 25, 2016 meeting, Union and HONI also agreed to complete an AC interference study. Union provided a form to HONI to collect the power line data necessary to initiate the study. This is the first step in the process to determine what the potential impacts may be and to develop any mitigation measures that may be necessary. The next step is for HONI to provide Union with design information which can be used to complete the AC interference study. Despite committing to provide this information HONI failed to do so until the afternoon of April 13, 2016; that is, until after it had filed its responding evidence.

16. Union next met with HONI on April 1, 2016. At the meeting HONI indicated, for the first time, that it was no longer prepared to relocate its towers. Both parties again agreed that an AC

interference study would be necessary to establish the safe separation and mitigation measures that may be required.

17. The Municipality was not able to attend this meeting but did send the e mail that can be found at Schedule 2.

18. Minutes of the meeting between HONI and Union are attached as Schedule 3. As reflected in the Minutes, a significant item of discussion was the separation between the pipeline and the hydro towers.

19. In HONI's intervenor evidence at page 2 it states that the pipeline and hydro towers could be as close as 1 meter. HONI has provided no evidence of this and such a proximity was not discussed at the meeting. On the contrary, HONI has provided hydro tower design information including centerline and foundation dimensions that indicates otherwise. Union has a 5 meter easement and intends to place its pipeline within its easement to maximize the practical separation between facilities. On this basis, Union believes that the separation will be approximately 5 meters.

20. Page 1 of HONI's intervenor evidence refers to the "CSA Principles and Practices of Electrical Coordination between Pipelines and Electric Supply Lines". That document sets out a recommended separation of 10m between pipelines and hydro towers as a conservative distance. As set out above, it is Union's practice to conduct an AC interference study whenever its pipelines share a corridor with hydro towers regardless of the potential separation.

Mitigation may be necessary for separation greater, or lesser, than 10 meters. It may also be used, in Union's experience, to safely decrease the distance between facilities to less than 10 meters.

21. An example of an AC interference study prepared for Union is attached as Schedule 4. It is a study in relation to Union's existing NPS 8 pipeline constructed more than 30 years ago that is located approximately 1-2 meters west of the corridor and HONI's proposed SECTR Project.

ENGINEERING CONSULTANT

22. Union agrees with HONI's position that an AC interference study is required. Union has retained Corrosion Service (formerly CORRENG) to complete this work.

23. Corrosion Service has extensive experience in completing AC interference studies.

24. Corrosion Service will complete the AC interference study in accordance with C22.3 No.6-13 Principles and practices of electrical coordination between pipelines and electric supply lines.

25. Attached as Schedule 5 is a letter from Corrosion Service. The letter sets out:

- the qualifications of Corrosion Service and its principal Bob Gummow;
- examples of potential mitigation measures which could be implemented;
- examples of past projects in which Corrosion Service has been involved with which are similar to the current situation.

26. As described in the letter, Corrosion Service "*are confident that the actual safe separation distance for the subject situation can be calculated, providing the powerline company is forthcoming with the pertinent power line operating parameters as outlined in Section E.2.2.3 of the CSA standard. The actual safe separation distance could be less than 10m. Preliminary calculations indicate that the safe separation distance would be less than 3m, based on information received from Hydro One on April 13, 2016.*"

27. Union received the Power line data information from HONI on April 13, 2016. Union forwarded this information to Corrosion Service to confirm its completeness. Once confirmed the AC interference study will be initiated.

EVIDENCE AND INTERROGATORY UPDATES

28. Union now has signed contracts with all of the 55 greenhouse growers that it was negotiating contracts with. Attached as Schedule 6 is a revised response to Board Staff Interrogatory 3. The response to OGVG interrogatory 4b should also be updated to confirm that that all contracts have now been signed.

29. Unions pre filed evidence at paragraph 46 on lines 15 and 16 of page 7 should be corrected to read "from a low of 2700 m3/hour to a high of 4780 m3/hour". This change reflects the actual volumes that are identified in the final signed contracts.

SUMMARY

30. Union has signed contracts in place for all of the new capacity created by proposed facilities. The Greenhouse growers are expecting the capacity to be available on November 1, 2016.

31. Union has worked with the Municipality of Leamington, the owner of the abandoned rail corridor, to determine the location of the proposed facilities and has signed easements in place.

32. The CSA standard allows for Pipelines and Transmission towers to be located in close proximity to each other if an AC interference study is completed.

33. Union has retained Corrosion Service a highly experienced engineering consulting firm to complete the AC interference study necessary so that the proposed facilities of both Union and HONI can co–exist safely in the corridor.

34. Union commits to implementing any recommendations that are made in the Corrosion Service report.


County Rd 14 – Facing South
5m Union Gas
Easement
C/L of 30" Water Main
8" Gas Main
Westerly Limit

From: Robert Sharon
To: Hammell, Paul; Grochmal, Tom; Simpson, Carl; John Pilmer; mehrgan.mazaheri@HydroOne.com; Constantin.Culinescu@HydroOne.com; Andrew.Luis@HydroOne.com; patricia.staite@HydroOne.com; ali.afshar@HydroOne.com
Subject: RE: Follow Up Meeting on Leamington Projects - Union Gas and Hydro One
Date: March-23-16 4:28:52 PM

Good Afternoon

Unfortunately I am unable to attend this meeting due to a prior commitment.

I did however want to provide comment that may assist in the discussion next Friday and help both parties move towards a resolution.

The Municipality of Leamington entered into an easement agreement with Union Gas to permit the construction of the natural gas pipeline within the municipally owned rail corridor in late 2015. Given this, and in recognizing where the two parties are in their respective planning and design processes, proposed construction timelines, and the available avenues to mitigate or eliminate setback concerns, the Municipality of Leamington will not oppose Union Gas installing their pipeline near the east edge of the trail per their current design.

Regards,

Rob Sharon

Robert Sharon, CMO
Director of Infrastructure Services
Municipality of Leamington
111 Erie Street North
Leamington, ON N8H 2Z9 Phone:

-----Original Appointment-----
From: Hammell, Paul [mailto:PHammell@uniongas.com]
Sent: Tuesday, March 22, 2016 9:55 AM

To: Hammell, Paul; Grochmal, Tom; Simpson, Carl; Robert Sharon; John Pilmer; mehrgan.mazaheri@HydroOne.com; Constantin.Culinescu@HydroOne.com; Andrew.Luis@HydroOne.com; patricia.staite@HydroOne.com; ali.afshar@HydroOne.com
Subject: Follow Up Meeting on Leamington Projects - Union Gas and Hydro One
When: Friday, April 01, 2016 10:30 AM-1:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: 109 Commissioners Rd, London, ON. N6A 4P1; UGL LOND Conference Room A6 with Projector

Hello,

This is a rescheduled meeting to discuss the Union Gas and Hydro One Leamington projects.

<u>Topics of Discussion</u>

- Design
- Hydro One update on any design changes since Feb 25th meeting
- Discuss separation between the facilities
- Field Activities
- Discuss timelines on field activities – pre-work, construction, etc.
- AC mitigation study
- Hydro One discuss when final design information should be ready to start AC mitigation study
- Union discuss timelines to complete AC mitigation study

The details of the meeting are:

Address: 109 Commissioners Rd, London, ON, N6A 4P1
Room: Conference Room A6
Date: April 1, 2016
Time: 10:30am-1:00pm

Please give me a call on my cell phone to let you into the building when you arrive.

Thanks,

Paul Hammell

MINUTES OF MEETING:	Project: SECTR (Leamington)	**FILE#:**	AR
DATE OF MEETING:	April 1st 2016	**Time of Meeting**	10:30am to 12:00pm
LOCATION:	Union Gas Office (London, ON)	**WRITTEN BY:**	Hamed Afshar
SUBJECT:	HONI Leamington Project	**SIGNATURE:**	

PRESENT:	Hamed Afshar Constantin Culinescu Patricia Staite Andrew Luis Tom Grochmal Carl Simpson Paul Hammell	Hydro One, PM (on behalf of Mehrgan Mazaheri) Hydro One, Lines Engineer Hydro One, Environmental Engineer Hydro One, Real Estate coordinator Union Gas, E&C Manager Union Gas, PM Manager Union Gas, PM

CC: - Mehrgan Mazaheri

Agenda No.	Agenda Description	Action	Date
1.	**Safety Minute**		
1.1	Safety Minute: - With BBQ season quickly approaching, people should be mindful of the BBQ brush they use. It has been reported that metal brush wires may fall off and end up on the food causing significant health hazards.	INFO	
2..0	**Status Updates & Points of Discussion**		
2.1	Both parties agreed on the importance of working together for the timing of construction. Hydro One said that it was not possible to work in the same areas at the same time because of the requirements for Notice of Project. Union Gas' Commercial Service dates Nov. 1 as the date to obtain gas and 5-6 months are required to construct. Hydro One plans to start in Jan. but it is dependent on land acquisition. It was noted that there would be no construction conflict if Union was able to construct in 2016 and Hydro One in 2017 and 2018.	INFO	
2.2	HONI design is roughly 90% complete. Some tower locations have been slightly adjusted but overall centerline remains the same. Hydro One has changed the tower design they plan on using since the last meeting to a pedestal style.	INFO	
2.3	Union Gas design for U/G pipes is complete. Union noted that they have all of the permanent and temporary land agreements in place to start construction.	INFO	

Agenda No.	Agenda Description	Action	Date
2.4	HONI is currently carrying out an archaeological study as per approved centerline. Other studies to follow.	Paul H.	
2.5	HONI has requested a copy of the archeology study that Union Gas is carrying out. Union Gas to provide a copy once the study is complete. HONI would appreciate a draft copy, once available.	Constantin C.	April 8, 2016
2.6	HONI to provide information required for Union Gas to carry out AC Mitigation study. The study takes into account arc flashes, fault current, and long term impact. HONI is currently working on it and will submit the information shortly.	INFO	
2.7	In regards to moving CL, HONI informed Union Gas that they did look at various options to accommodate UG but due to environmental & regulatory approvals, changing the centerline is not an option.	Paul H/ Constantin	April 15, 2016
2.8	In regards Union's proposed pipeline location and alternatives considered, Union informed HONI that the chosen location resulted from field studies, detailed engineering, and negotiations with the municipality.	INFO	
2.9		INFO	
3.0	HONI inquired about construction requirements in case of travelling over Union Gas Pipelines. Union Gas to review requirements and advise once HONI informs them of the type of construction equipment.	INFO	
	HONI informed Union Gas that the trail would need to be restored following completion of underground pipeline construction.		
	HONI also proposed that in case of Union Gas maintaining their CL, the portion of work Parallel to HONI CL should be completed first. ~~Union Gas confirmed.~~ Union Gas confirmed that all their pipeline construction would be complete by end of 2016 in order to not impact HONI's construction in 2017.		
	Based on conclusion and recommendations of AC mitigation study, the appropriate course of action will be determined in cooperation between HONI and Union Gas.		
3.0	**Next Meeting**		
3.1	TBD	INFO	

The foregoing represents Hydro One project manager's understanding of major items of discussion and the decisions reached and/or future actions required. If above does not accurately represent the understanding of all parties attending, please notify Hamed Afshar within 3 days of receiving these minutes.

CORRENG

Final Report

AC Interference Study on the UGL Leamington North Pipeline Related to the New 230 kV Hydro One Line Leamington, Ontario

September 2009
COR-09-10323-U-0

Prepared for:

Union Gas Limited
50 Keil Drive North
Chatham, ON
N7M 5M1

Prepared by:

F. Shahinas, E.I.T.
Systems Specialist

Reviewed by:

W. Fieltsch, P.Eng.
Manager
NACE Cathodic Protection Specialist No. 7605

CORRENG Consulting Service Inc.
205 Riviera Drive, Markham, Ontario, L3R 5J8, Canada

REVISIONS TABLE				
Sept 2009	Issued for Approval	FS	WF	
Date	**Description**	**Prepared by**	**Reviewed by**	**Approved by**

Table of Contents

EXECUTIVE SUMMARY

CORRENG Consulting Service Inc. was retained by Union Gas Limited to perform an AC interference study on the effects of the proposed new Hydro One 230 kV transmission line on the existing UGL Leamington North pipeline in southern Ontario.

The objectives of the mitigation design were to mitigate the AC induced voltages to safe limits under steady-state and fault conditions, to avoid an arc striking between any grounded part of a powerline tower and the pipeline, to avoid excessive coating stress and to minimize the risk of AC-enhanced corrosion on the pipeline.

Mitigation of possible DC interference from the pipeline cathodic protection system on the powerline structures and grounding electrodes is also included as part of this project.

The AC potentials under steady-state and fault conditions along the Leamington North pipeline were calculated using the PRCI AC Coupling Prediction program.[1] Fault locations were selected at the start, middle and end of the common right-of-way as well as UGL stations and powerline crossings along this section.

The maximum predicted AC voltages under steady-state conditions were less than the 15V safety limit at all locations along the pipeline.

The maximum predicted AC current density was 206 A/m^2. The proposed 50 A/m^2 limit was exceeded from Ch. 0 to 2+640, Ch. 9+545 to 9+725, and Ch. 12+518 to 15+325. At these levels, it is likely that AC-enhanced corrosion will occur.

The predicted unmitigated AC induced voltages under fault conditions were above the safety limits at UGL stations 05E-403 (Ch. 0), 04E-401 (Ch. 12+518), 04D-601 (Ch. 13+934) and 03D-301 (Ch. 16+641). The 2000V coating stress limit for coal tar enamel coating was exceeded from Ch. 0 to 0+920 and Ch. 10+974 to 16+641. The touch limit for test posts in open field was also exceeded at all locations along the shared right-of-way.

Based on the information received to date, the separation between the pipeline and the grounding of the new 230 kV powerline is greater than the 18 m recommended in the CEA report 239T817 – *Powerline Ground Fault Effects on Pipelines*, so there is no risk of electrical arcing. Should this separation be less than the recommended values at one of the crossings or at some other location, additional calculations should be conducted to determine the actual voltage between the grounded structure and pipeline to establish whether mitigation measures would be required.

[1] As prepared for the Corrosion Supervisory Committee PRC International. American Gas Association by Electro Sciences Inc. May 1999, PR-200-9414.

The mitigation requirements along the pipeline are summarized in the table below:

Pipe Chainage (m)	Location	Mitigation Description
1+130	At South Middle Road	Install a bank of ten (Qty. 10) packaged (20-60) magnesium anodes at 10 m spacing or 80 m of zinc ribbon in sacrificial anode backfill.
12+518	At UGL Station 04E-401	Install a bank of eighteen (Qty. 18) packaged (20-60) magnesium anodes at 10 m spacing or 120 m of zinc ribbon in sacrificial anode backfill.
216 to 12+518	Test Posts	All test stations along the pipeline shall be installed with gradient control grids or shall be of dead-front type construction (subject to Owner Approval).

The proposed mitigation system would mitigate AC current densities to below the 50 A/m^2 limit along the entire pipeline to minimize the risk of AC-enhanced corrosion. Assuming a 150 mm layer of crushed stone at all stations, the mitigation system would also serve to protect personnel under fault conditions by lowering touch potentials to below the 1597 V safety limit and well below the 2000 V coating stress limit for coal tar enamel coatings. The 358 V safety limit for test stations would still be exceeded along the entire shared right-of-way. As a result, all test posts should be equipped with gradient control grids or be of dead-front type.

It is also recommended that a new DC decoupler be installed at Comber Station between the pipelines and the station ground to replace the failed polarization cell installed for AC mitigation of the Panhandle Line.

DC interference testing should be conducted on the grounding electrodes and the anchors of the powerline structures interconnected via sky wires or grounding conductors. The recommended procedure is detailed in Section 11 of this report.

1.0 GENERAL

CORRENG Consulting Service Inc. was retained by Union Gas Limited to perform an AC interference study on the effects of the proposed new Hydro One 230 kV transmission line on the existing Leamington North pipeline in southern Ontario.

The objectives of the mitigation design were to mitigate the AC induced voltages to safe limits under steady-state and fault conditions, to avoid an arc striking between any grounded part of a powerline tower and the pipeline, to avoid excessive coating stress and to minimize the risk of AC-enhanced corrosion on the pipeline.

Mitigation of possible DC interference from the pipeline cathodic protection system on the parallel powerline structures (towers or poles) and grounding electrodes is also included as part of this project.

2.0 EFFECTS OF AC INTERFERENCE

A pipeline which runs in the proximity of a high voltage powerline is subject to voltages induced by magnetic coupling. These AC induced voltages (V_{AC}) appear both under steady-state and fault conditions and their magnitude depends on the phase current, on the length of parallelism, on the distance between pipeline and powerline and on the pipeline-powerline configuration. The induced voltages reach maximum values at discontinuities[2] and gradually attenuate along the pipeline.

A second type of AC interference on the pipelines, defined as "conductive coupling", only appears under powerline fault conditions. The fault current flowing through the grounding of the high voltage structure (i.e. pole or tower) produces a potential rise in the neighboring soil defined as "ground potential rise" (i.e. GPR). Part of this rise is transferred to the pipe (V_{tr}) and would be added to the AC induced voltage.

The pipe voltage (V_{pipe}) is typically defined as the pipe voltage with respect to close ground (V_{P-CG}) and is the difference between the potential of the pipe itself (i.e. pipe metal) and the potential of the ground.

Under steady-state conditions, the AC interference could result in safety problems for people coming in contact with the metallic pipe or its appurtenances and in accelerated corrosion on the underground section of the pipe (i.e. AC-enhanced corrosion).

Under fault conditions, the AC interference could result in damage to the pipe itself (i.e. electrical arc between the structure grounding and the pipe), in safety concerns for pipeline personnel and in damage to pipeline coating.

[2] Start and end of the common ROW, phase transpositions, isolating flanges on the pipeline, etc.

The hazards generated by AC interference are summarized in Table 1.

Table 1. AC Interference Hazards

Condition	Hazard	Relevant Parameter	Symbol	Notes
Steady-State	Shock to Personnel	Touch Voltage	V_{touch}	Considered equal to V_{AC}
	AC-enhanced Corrosion	Current Density at Holidays	i_{AC}	Derived from the V_{AC} and soil resistivity
Fault	Shock to Personnel	Touch Voltage	V_{touch}	Considered equal to V_{pipe} (or V_{P-CG})
	Power Arc	Pole/Tower Grounding Voltage	V_G	Derived from fault current, grounding electrode data, soil resistivity, etc. Cannot exceed the phase-to-ground voltage.
	Coating Stress	Coating Stress Voltage	V_{stress}	Equals to V_{pipe} (or V_{P-CG})

3.0 ADMISSIBLE LIMITS

3.1 Shock to Personnel

3.1.1 Steady-State Conditions

The AC induced voltages under steady-state conditions shall not exceed 15V at above-grade appurtenances and 50V along the underground sections of the pipeline in order to avoid an electrical shock to pipe personnel or to the general public.

3.1.2 Fault Conditions

The recommended safety limits for AC voltage under fault conditions were calculated using the conservative methodology specified in IEEE Standard 80 "Guide for Safety in AC Substation Grounding":

$$V_{touch} = \frac{116 + 0.17 \times \rho}{\sqrt{t_f}}$$, for a person with a 50 kg body weight in uniform soil

and

$$V_{touch} = (1000 + 1.5 \times \rho_s \times C_s) \times \frac{0.116}{\sqrt{t_f}}$$, for a person with a 50 kg body weight standing on a 0.15m layer of crushed stone[3]

[3] An isolating layer of crushed stone inside the station significantly reduces the current through the body in the event of contact with an A/G appurtenance, when the pipeline voltage rises due to a fault on the HV powerline.

where:

t_f = duration of the fault = 0.105s (for Primary Protection[4])
ρ = soil resistivity,varies with the location. A minimum value of 0 Ω-m would be considered as the worst case for safety limit calculations
ρ_s = resistivity of the crushed stone layer = 3000Ω-m
C_s = corrective factor, calculated as:

$$C_s = 1 - \frac{0.09 \times \left(1 - \frac{\rho}{\rho_s}\right)}{2 \times h_s + 0.09}$$

h_s = thickness of the crushed stone layer = 0.15m

The calculated limits are 358V for test posts located in open field and 1597V for stations with a layer of crushed stone.

3.2 AC-Enhanced Corrosion

According to literature,[5] there is no risk of AC-enhanced corrosion (ACEC) for AC current densities less than 20 A/m^2, the ACEC is unpredictable for AC current densities between 20-100 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 was selected as the worst case value for our calculations.

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

$$i_{ac} = \frac{8 \times V_{ac}}{\rho \times \pi \times d}$$

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

[4] The probability of a person touching the pipeline during a fault in conjunction with a failure of the communication link between the breakers is negligible.
[5] Prinz, W – AC Induced Corrosion on Cathodically Protected Pipelines, UK Corrosion 92,Vol. 1

3.3 Arcing Under Fault Conditions

CEA report 239T817 – *Powerline Ground Fault Effects on Pipelines* describes the tests that were conducted to determine the voltages required to strike an arc to a pipeline through various soil types over a range of distances. The test results were extrapolated to determine recommended minimum separation distances between pipelines and grounded powerline structures at transmission line voltages ranging from 138 kV to 500 kV. The predicted safe separation distances to prevent a sustained arc (i.e. an arc initiated by lightning and sustained by the fault current) are as shown in Table 2. The calculated distances in feet were added in brackets for convenience.

Table 2. Safe Separation Distances

System Voltage (kV)	Predicted Maximum Sustained Arc Length (m)
144	11 (36 ft)
230	18 (59 ft)
500	41 (135 ft)

3.4 Coating Stress Under Fault Conditions

When a fault occurs on the powerline and the potential difference between the pipe and the ground exceeds the dielectric strength of the coating, the subsequent current transfer between the pipe and ground could damage the coating.

NACE Standard SP0177-2007 – *Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems* specifies threshold values of 2 kV, 3 kV and 5 kV for coal tar enamels, fusion bond epoxy and polyethylene coatings, respectively.

4.0 DESIGN DATA AND ASSUMPTIONS

4.1 Pipeline Data

The 8" diameter Leamington North pipeline was installed in 1968, starting from the 10" Windsor Line in Lot 16, south of Middle Road and ending at the Leamington Gate Station. In 1970, the line was split into two segments, to be separately connected to the Comber Station. The southern segment was connected to the station in 1970 via a 10" diameter, 205.1 m long line to complete the 8"/10" diameter, 16.64 km long Leamington North pipeline. The remaining northern section was connected to the Comber Station in 1972 via a 8" diameter, 215 m long line to complete the 8" diameter, 587 m long Leamington North – Windsor Line Tie-Over pipeline.

At Comber Station, the Leamington North Line, the Windsor Tie-Over Line and the Panhandle Line are isolated from the station ground. However, they are bonded together via a bond box inside the station making them electrically continuous with each other for the purpose of a shared, impressed current cathodic protection system. On the other end of the

Leamington North line is Leamington North Gate Station where the line is also isolated from the station ground.

The pipeline is coated with coal tar enamel for the most part, with a short (120 m) yellow jacket section installed in 1999. The pipeline is assumed to have a coating resistance of 20 $k\Omega\text{-}m^2$ and assumed to be installed at an average depth of 1.1 m measured to the center of the pipe in the open trench sections.

4.2 Soil Resistivity

Soil resistivity values were measured using the Wenner 4-pin method at 5', 10', and 15' spacings, during a site survey in July 2004 by Corrosion Service personnel, as part of an ECDA study. The measured soil resistivities along the Leamington North pipeline are provided in Table 3.

Table 3. Soil Resistivity Data.

Chainage	Resistivity (ohm-cm)			Layers			Notes
	5ft	10ft	15ft	First Layer (ohm-m)	Depth (m)	Second Layer (ohm-m)	
1+157	1800	2300	3200	16	2.4	96	TP 2
3+109	2300	2900	4000	21	2.4	110	TP 2.1
4+307	2100	2700	3200	19	1.8	50	TP 3
5+570	1700	2300	2900	15	2	61	TP 4
6+984	1900	2700	2900	15	1.3	40	TP 5
8+349	2100	2500	2900	20	2.1	41	TP 6
9+723	1900	2700	3200	17	1.8	58	TP 7
11+119	6500	5200	3400	70	2.8	10	TP 8
12+545	3400	3800	4300	33	2.2	56	TP 9
13+949	1100	1900	2000	8	1.2	36	TP 10
15+340	5900	7100	7500	54	1.5	89	TP 11
15+813	8200	10500	10100	94			HWY 3

The soil resistivities are quite low for most of this section and generally consistent, ranging from 1500 ohm-cm to 9400 ohm-cm for the entire length of the line, and averaging about 2500 ohm-cm along the shared right-of-way.

4.3 Powerline Data

The powerline data for the proposed line was obtained from Hydro One and is summarized in Tables 4 and 5 below.

Table 4. Powerline Parameters

Power Line Parameter	New Powerline 7L131/7L106	Notes
Voltage (kV)	230 kV (nominal) 250 kV (max)	
Powerline Section	Leamington JCT x Leamington TS	
Pole Nos.	N/A	
North Star Pipe Chainage (km)	0+216 – 12+518	Parallel Sections
Pole Material	Steel Lattice	
Sky/Shield Wire	Double	
Grounding	Max. 20 ohms	Auger foundation
Maximum Phase Current (A)	250 A (100MVA)	Peak projected phase current
Average Phase Current (A)	188 A (75 MVA)	Average projected phase current
Conductor Configuration & Phasing	A C B B C A	Phasing looking south (to Leamington Station)
Phase Transposition	None	
Avg. Conductor Height (m)	24.1/17.1/10	
Fault Current (kA)	Varies by location	See Table 5
Fault Duration (s)	0.105 s	Maximum primary protection

Table 5. Projected Fault Currents for New Hydro One Powerline

Location	Line	Phase-to-Ground Fault Current (A)		
		From Tap Point	From Substation	Total
At Beginning of Common ROW (0+216)	L1	7435.2	516.6	7952
	L2	7292.7	522.4	7815
At Middle of Common ROW	L1	6179.8	536.9	6717
	L2	6080.4	541.6	6622
At End of Common ROW (12+518)	L1	5285.8	554.3	5840
	L2	5212.4	558.1	5771

It should be noted that the line carrying the highest fault current was used in the fault calculations. Also, fault currents at stations and other points of interest along the common right-of-way were calculated by performing a linear interpolation of the three values above.

4.4 Right-of-way Configuration

Figure 1 depicts the pipeline/powerline right-of-way configuration for the new Hydro One 230 kV line, which is routed in a common corridor with the Leamington North pipeline from Ch. 0+216 to Ch. 12+518.

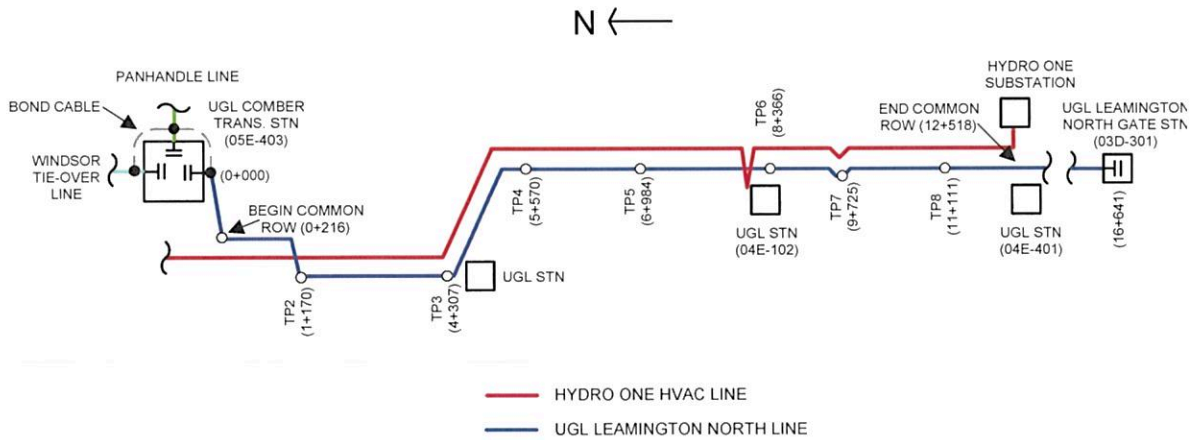

Figure 1. Pipeline/Powerline Configuration

5.0 RISK OF SHOCK TO PERSONNEL UNDER UNMITIGATED AC INFLUENCE

5.1 General

The touch voltages under steady-state and fault conditions along the Leamington North pipeline were calculated using the PRCI AC Coupling Prediction program.[1] The data is summarized below.

For steady-state conditions, the maximum load of 250 A was used for induced voltage calculations, as it represents the worst case scenario.

The fault locations were typically selected at the start and end of the common right-of-way, at locations where the pipeline is running in close proximity to a tower, near a pipeline powerline crossing, and at the closest towers to a valve or a transmission station.

5.2 Steady-State Conditions

The predicted AC voltage profiles for this configuration (250 A operation) are shown in Figure 2 with respect to the pipeline chainages. The 15 V safety limit is marked for reference.

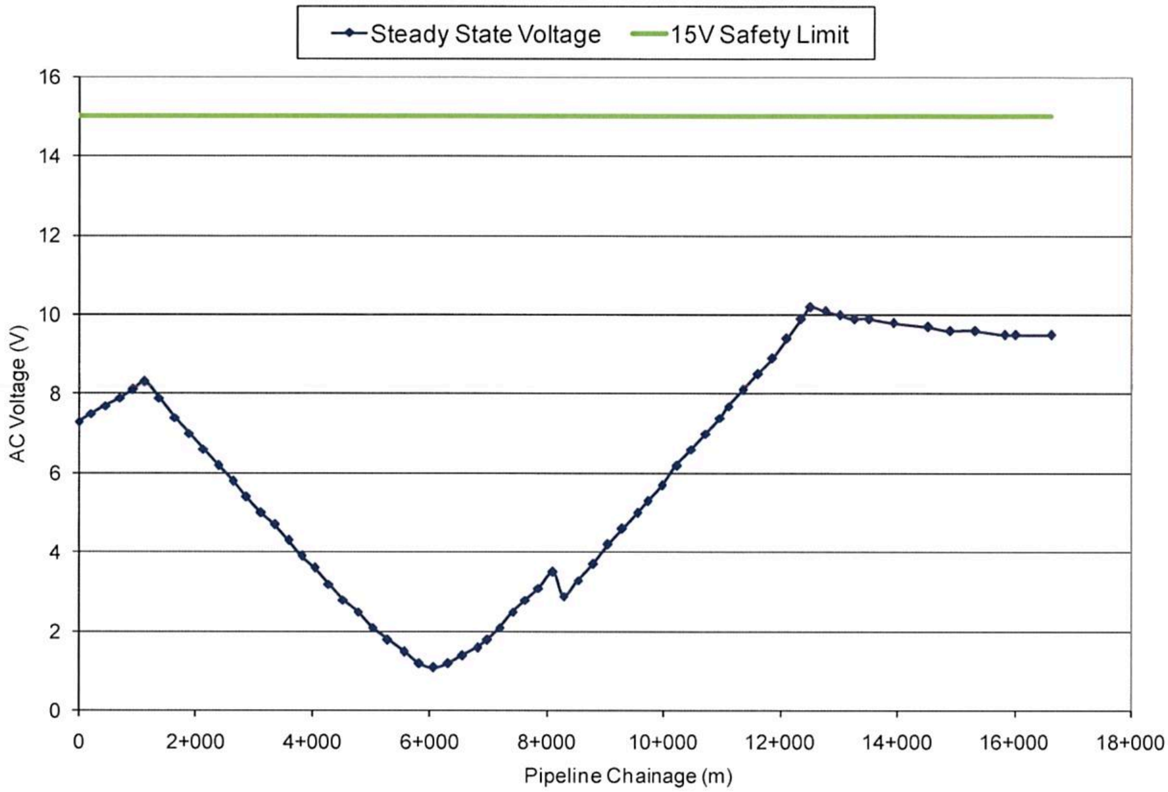

Figure 2. Predicted Unmitigated Maximum AC Voltages (Steady-State)

The predicted AC voltages under steady-state conditions are substantially less than the 15 VAC safety limit for the entire length of the pipeline.

5.3 Phase-to-Ground Fault Conditions

The following fault locations were selected for the new powerline:

- Ch. 1+130: Beginning of common ROW and HVAC line crossing
- Ch. 4+284: UGL Station and pipeline bend
- Ch. 6+819: Middle of common ROW
- Ch. 8+293: UGL Station and HVAC line crossing
- Ch. 12+518: End of common ROW and HVAC substation

The unmitigated touch voltages predicted by the PRCI software under a phase-to-ground fault at the above locations are shown in Figure 3 below. The 318 V safe touch potential limit for test stations and the 1597 V safe touch potential limit for stations were included for reference.

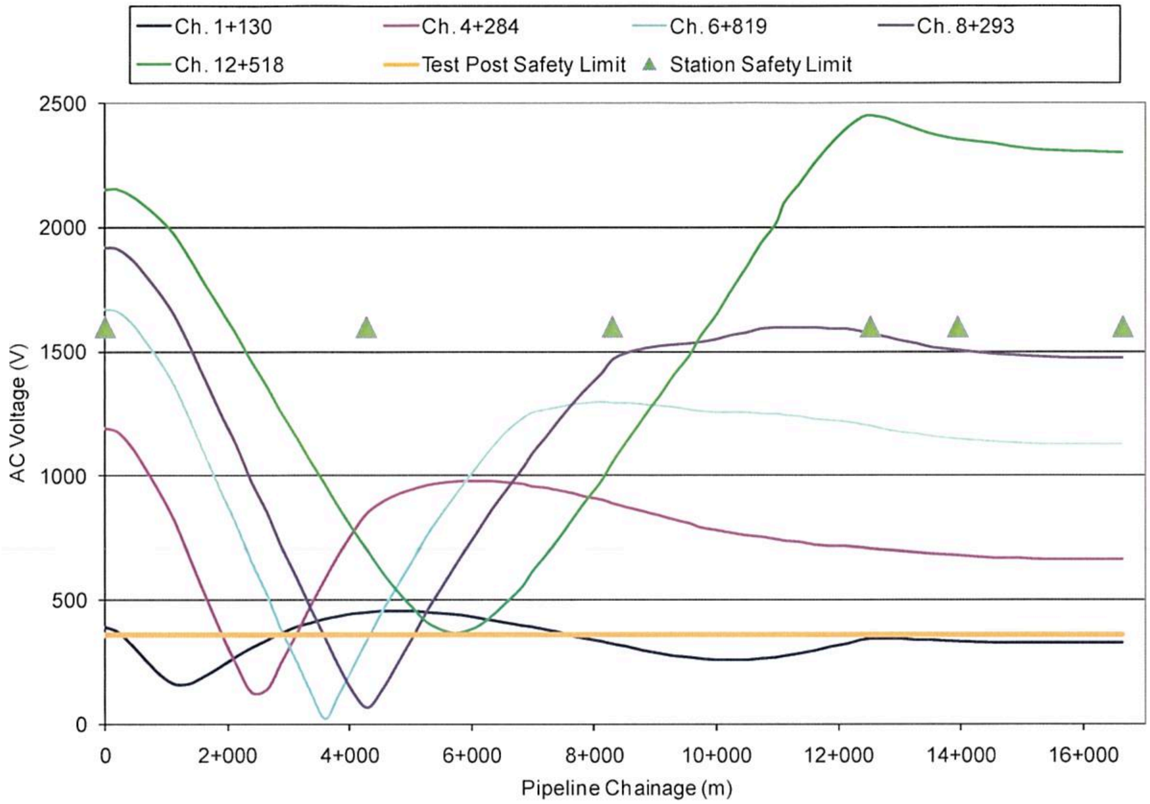

Figure 3. Predicted Unmitigated Touch Voltages

As shown, the unmitigated touch voltages were above the 1597 V safety limit (assuming a 150 mm layer of crushed stone), at UGL stations 05E-403 (Ch. 0), 04E-401 (Ch. 12+518), 04D-601 (Ch. 13+934) and 03D-301 (Ch. 16+641). The 358 V touch limit for test stations in open field was exceeded along the entire common right-of-way.

6.0 RISK OF AC-ENHANCED CORROSION

The risk of AC-enhanced corrosion (ACEC) was assessed by calculating the maximum AC current density at a $1 cm^2$ holiday as indicated in paragraph 3.2 and comparing with the limits indicated in literature.[5] Since AC corrosion is a cumulative process, the average phase current (188 A) was used to calculate the AC induced voltage.

Although ACEC is unpredictable for AC current densities in the range between 20-100 A/m^2, we recommend that the risk of ACEC be minimized by mitigating the AC current densities to below 50 A/m^2.

The predicted AC current densities due to the new 230kV line installation are plotted in Figure 4. The 50 A/m^2 threshold for ACEC is added for reference.

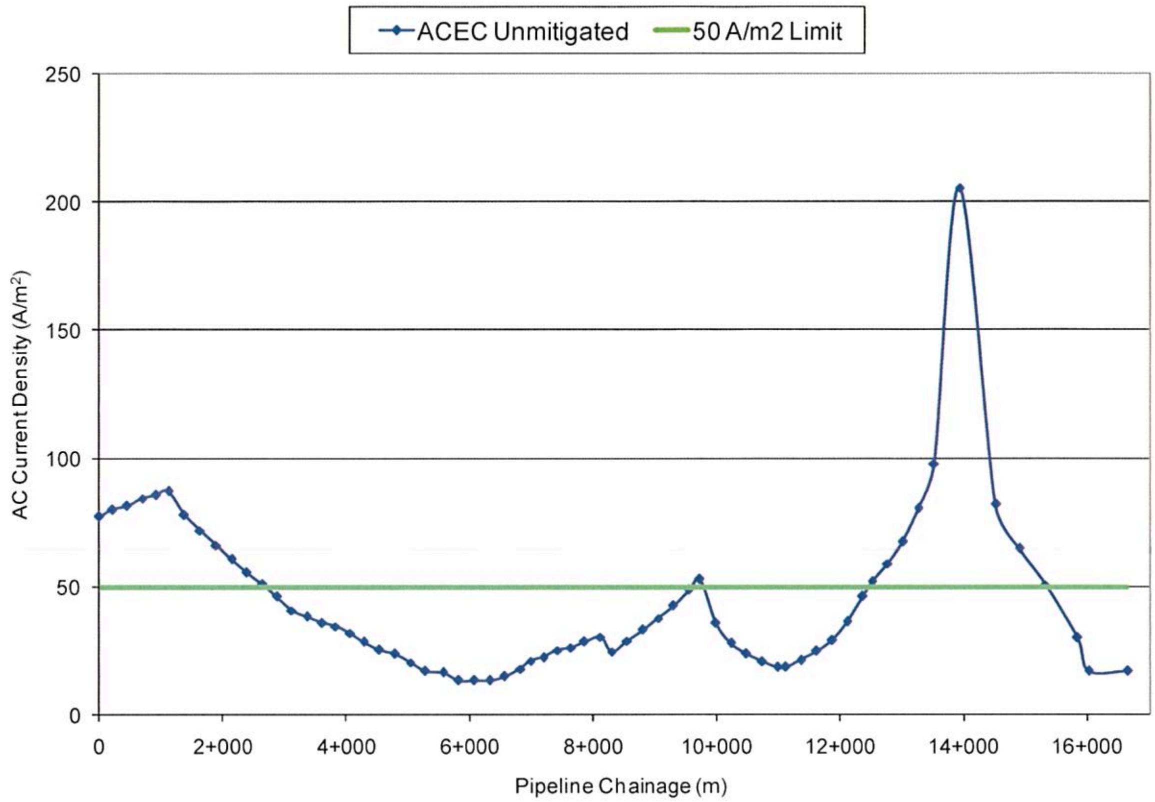

Figure 4. Predicted Unmitigated AC Current Densities

The installation of the new powerline results in AC current densities that exceeded the 50 A/m^2 limit from Ch. 0 to 2+640, Ch. 9+545 to 9+725, and Ch. 12+518 to 15+325. The maximum calculated AC current density occurred at Ch. 13+934 and was 206 A/m^2.

7.0 RISK OF ARCING UNDER FAULT CONDITIONS

Based on the layout drawings, the separation distance between the pipeline and the new 230 kV powerline grounding exceed the 18 m recommended in the CEA report 239T817 – *Powerline Ground Fault Effects on Pipelines*, therefore there is no risk of arcing under fault conditions.

Should this separation be less than the recommended values at one of the crossings or in a paralleling section, additional calculations should be conducted to determine the actual voltage between the grounded structure and pipeline to establish whether mitigation measures would be required.

8.0 RISK OF COATING STRESS UNDER FAULT CONDITIONS

The coating stress under fault conditions along the Leamington North pipeline was calculated using the PRCI AC Coupling Prediction program[1] and the maximum fault currents based on Table 5 of this report.

As shown in Figure 3 above, the 2000 V coating stress limit for coal tar enamel was exceeded between Ch. 0 to 0+920 and Ch. 10+974 to 16+641. The maximum coating stress was at Ch. 12+518 and was 2451 V. As such, there is a risk of coating stress damage along this pipeline.

9.0 MITIGATION OF AC EFFECTS

The recommended mitigation measures intended to limit the AC Voltages to safe limits under fault conditions, and minimize the risk of AC-enhanced corrosion, are summarized in Table 6.

Table 6. Summary of Mitigation Measures

Pipe Chainage (m)	Location	Mitigation Description
1+130	At South Middle Road	Install a bank of ten (Qty. 10) packaged (20-60) magnesium anodes at 10 m spacing or 80 m of zinc ribbon in sacrificial anode backfill.
12+518	At UGL Station 04E-401	Install a bank of eighteen (Qty. 18) packaged (20-60) magnesium anodes at 10 m spacing or 120 m of zinc ribbon in sacrificial anode backfill.
216 to 12+518	Test Posts	All test stations along the pipeline shall be installed with gradient control grids or shall be of dead-front type construction (subject to Owner Approval).

It is recommended that a bank of anodes be installed at Ch. 1+130 m and another bank at Ch. 12+518 to minimize the risk of AC-enhanced corrosion by mitigating the AC current densities to below 50 A/m^2. The banks should contain ten (10) and eighteen (18) packaged 20 lb. magnesium anodes, respectively, spaced at 10 m intervals. Connection to the pipeline should be via a test station or junction box. Alternatively, zinc ribbon in select backfill can be used.

Mitigation measures to protect personnel from touch potentials under fault conditions at test posts are also required. Test posts along the shared common right-of-way should be installed with gradient control grids. Alternatively, with owner approval, dead-front test stations may be used instead of gradient control grids.

It is also recommended that a new DC decoupler be installed at Comber Station between the pipelines and the station ground to replace the failed polarization cell installed for AC mitigation of the Panhandle Line.

10.0 PREDICTED MITIGATED AC VOLTAGES

10.1 Steady-State Conditions

The predicted mitigated AC Voltage profile for the new configuration along with the 15V safety limit is shown in Figure 5.

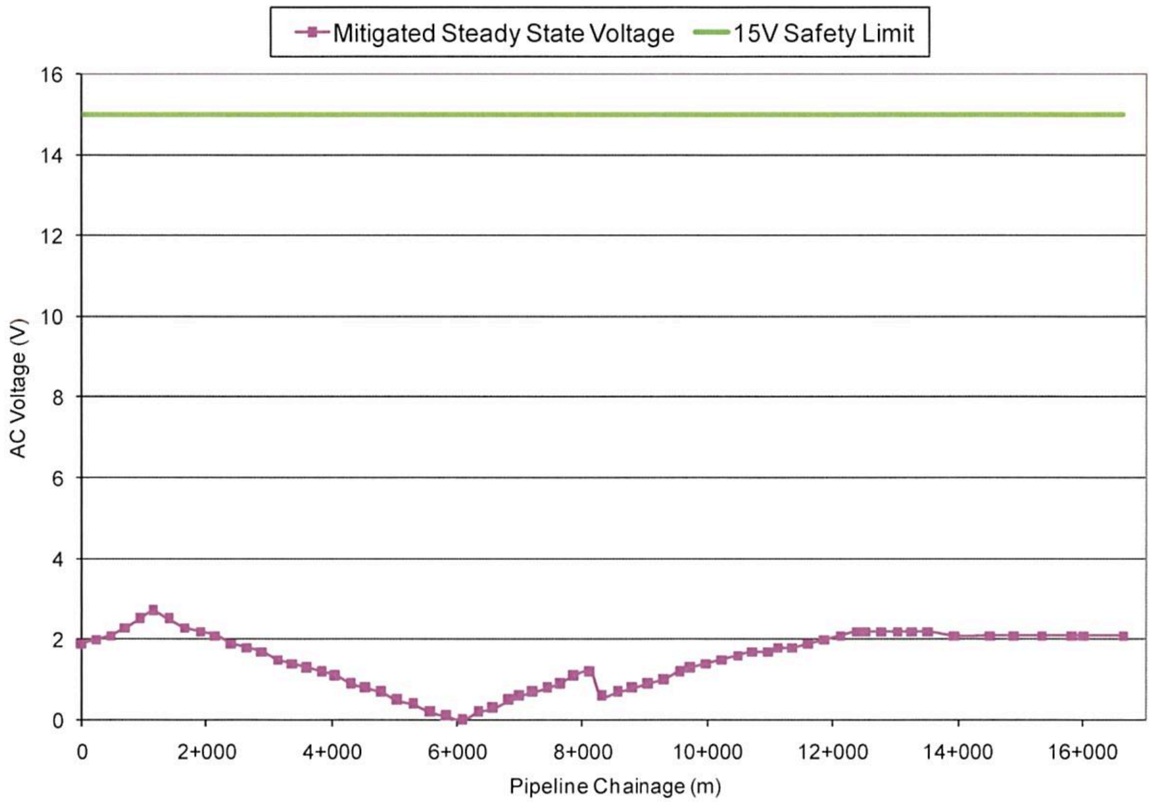

Figure 5. Predicted Mitigated AC Voltages (Steady-State)

The predicted mitigated AC induced Voltages under steady-state conditions remain less than 15V safety limit at all locations.

The predicted mitigated AC current densities are plotted in Figure 6. The proposed 50 A/m^2 threshold for ACEC is added for reference.

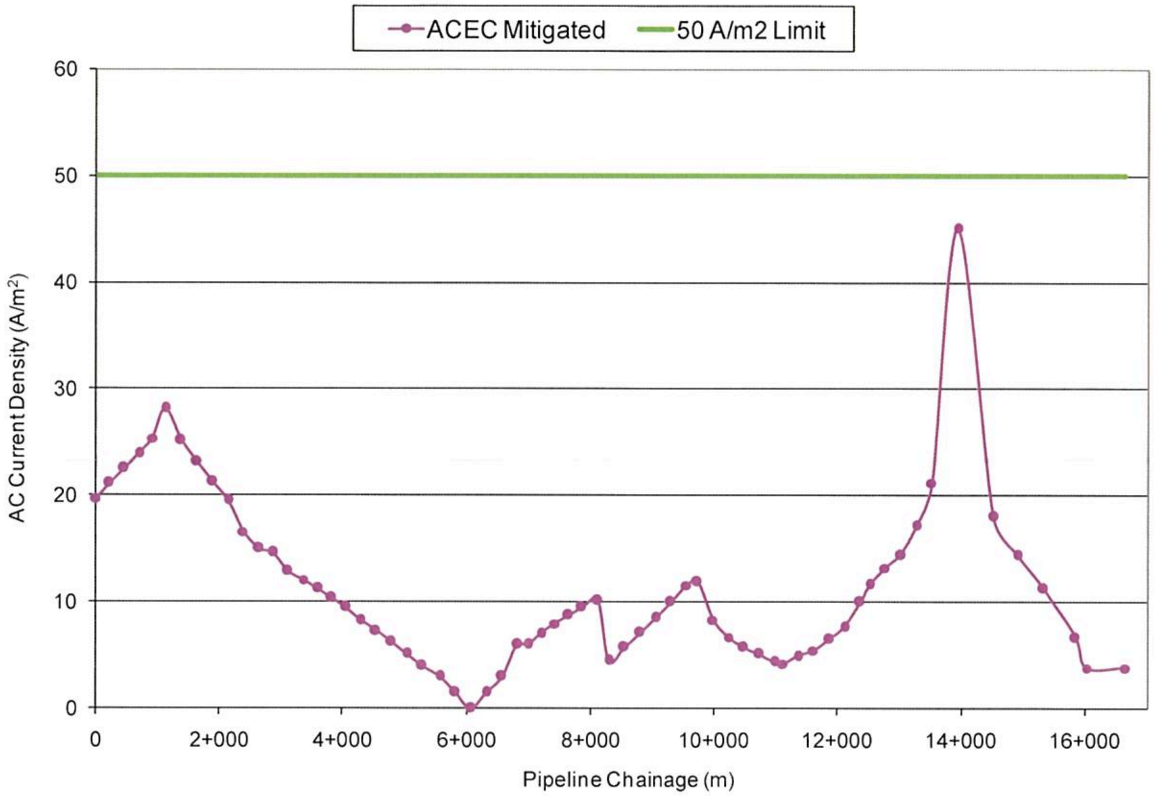

Figure 6. Predicted Mitigated AC Current Densities

The predicted mitigated current densities will be below the 50 A/m^2 limit along the entire pipeline.

10.2 Phase-to-Ground Fault Conditions

The mitigated touch voltages predicted by the PRCI software under a phase-to-ground fault at the indicated fault locations for the new powerline are shown in Figure 7.

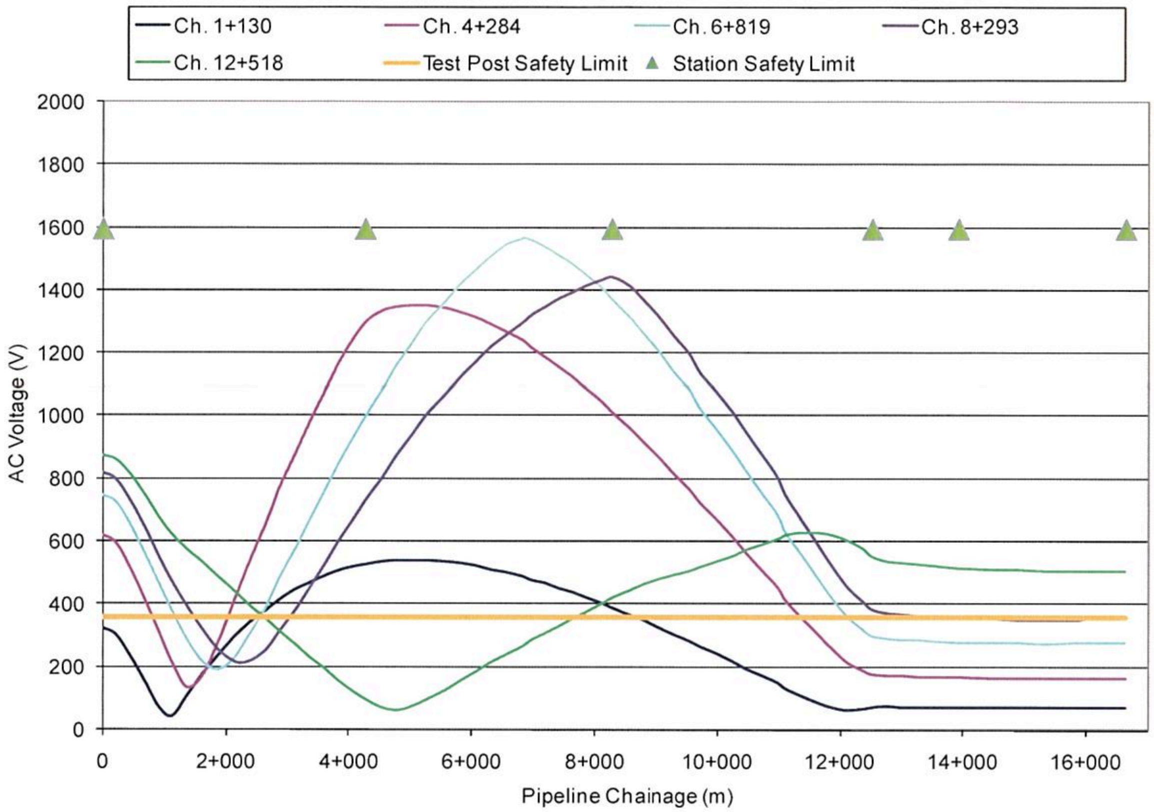

Figure 7. Predicted Mitigated Touch Voltages

The mitigated touch voltages were less than the safety limit for stations (1597V) and less than the coating stress limit (2000V) along the entire pipeline. The 358V touch limit for test stations in open field was exceeded along the entire common right-of-way. Therefore, gradient control mats or dead-front test stations should be provided to prevent shock to personnel in these areas.

11.0 RISK OF DC INTERFERENCE ON THE POWERLINE POLES

When a powerline structure (tower or pole) is located relatively close to the groundbed of an impressed current system and the protected pipeline and the powerline are parallel, a portion of the current discharged by the groundbed could be picked up by the grounding electrode or the tower foundations near the groundbed. This stray current could then travel through the sky wire along the powerline and be discharged back to the pipeline via the grounding electrodes or the anchors or the foundations of other structures, resulting in accelerated corrosion at the discharge location (DC interference).

The Leamington North Line shares an impressed current system with the Panhandle Line and the Windsor Line. The closest rectifier is Rectifier #33 on the Windsor line, close to Comber Station. We recommend that interference tests be conducted during the commissioning of the CP system using the following procedure:

- Interrupt Rectifier #33
- Measure the on and off potentials of the grounding electrodes or the anchors at the closest structures to the pipeline near Comber Station.
- If no shift occurs in the potential, end the test.
- If the on-potential is more electropositive than the off-potential, measure the current and the direction of the DC current. If the grounding electrode or the anchor guy discharge more than 10 mA to the ground, install two 32 lb magnesium anodes in parallel with the grounding electrode.

12.0 CONCLUSIONS AND RECOMMENDATIONS

Although predicted AC induced voltages under steady-state conditions were significant with the proposed new 230kV line, they remained well below the 15V limit along the entire length of the pipeline.

The AC current densities, which increased to above the recommended 50 A/m^2 limit due to the new powerline, were mitigated to below 50 A/m^2 via installation of two banks of ten and eighteen packaged magnesium anodes at Ch. 1+130 and Ch. 12+518, respectively, minimizing the risk of AC-enhanced corrosion along the entire pipeline.

The mitigation also reduced touch potentials under fault conditions to below the admissible limits at all stations along the common right-of-way. The maximum coating stress was also reduced from 2451 V to 1565 V, well below the 2000V limit for coal tar enamel coatings.

As the distance between the paralleling powerlines and the pipelines are in excess of 18 m, there is no risk of electrical arcing and pipeline puncture. Should any HVAC towers at crossings or other locations be closer than the recommended separation distance, additional calculations should be conducted to determine the actual voltage between the grounded structure and pipeline to establish whether mitigation measures would be required.

All the test posts along the common right-of-way shall be installed with gradient control grids. Alternatively, dead-front test stations may be used instead of gradient control grids, subject to owner approval.

It is recommended that a new DC decoupler be installed at Comber Station between the pipelines and the station ground to replace the failed polarization cell installed for AC mitigation of the Panhandle Line.

DC interference testing should be conducted on the grounding electrodes and the anchors of the new powerline structures near Comber Station.

CORROSION SERVICE

April 14, 2016

Union Gas Limited
50 Keil Drive North
Chatham, ON
N7M 5M1

Attention: Tom Grochmal, Ph.D., P.Eng
Manager, Engineering Construction

Re: Union Gas Ltd. Application to Construct a Pipeline in the Municipality of Leamington – Hydro One Networks Intervenor Evidence and Witness Panel

To Whom It May Concern

Corrosion Service Company Limited (CSCL) has been supplying engineering services to pipeline companies to mitigate the adverse effects of both steady state induced AC and power line faults since 1978. During this 37 year period we have gained experience in calculating safe separation distances and designing mitigation methods to prevent the adverse effects. We have been providing this service to Union Gas Limited for over 25 years and have assessed several hundred pipeline/power line proximity conditions in order to determine a safe separation distance and to design mitigation facilities where necessary.

Clause 5.3 of CSA Standard C22.3 No.6-13[1] addresses methods of "reducing adverse effects during power line fault conditions" on nearby pipelines. The typical adverse effects on a coated steel pipeline include damage to the coating, melting of the steel pipe wall at defects in the coating, and producing a hazardous step and touch voltage to the public and pipeline operating personnel during a power line fault. To minimize these adverse effects the CSA standard recommends, in the absence of an agreement between the pipeline and powerline owners, that the separation distance between the powerline tower footings or grounding system and the pipeline be "not less than 10m" . The standard also suggests that it is difficult to quantify the safe separation distance but allows that 10m appears to be a conservative value.

We are confident that the actual safe separation distance for the subject situation can be calculated, providing the powerline company is forthcoming with the pertinent power line operating parameters as outlined in Section E.2.2.3 of the CSA standard. The actual safe separation distance could be less than 10m. Preliminary calculations indicate that the safe separation distance would be less than 3m, based on information received from Hydro One on April 13, 2016.

[1] CSA Standard C22.3 No. 6-13, Principles and practices of electrical coordination between pipelines and electrical supply lines, Canadian Standards Association, July, 2013

CORROSION SERVICE

Furthermore, where the safe separation distance cannot be obtained, mitigation measures can be designed to protect the pipeline during fault conditions, such as:

- Increasing the coating thickness to increase the coating dielectric strength to prevent coating breakdown due to voltage stress across the coating
- Installing an insulating casing around the pipe so as to eliminate an ionized soil path directly to the pipe, thereby negating the possibility of an arc strike to the pipe.

In addition, the power line company can also implement measures to minimize adverse effects as listed in Clause 6.3 of the CSA standard. Therefore, in our opinion, cooperation between the pipeline and power line operators and sound engineering practice can produce a safe situation for the coexistence of each facility on the right-of-way.

Yours truly
Corrosion Service Company Limited

R.A.Gummow, P.Eng
NACE Corrosion Specialist #710
for
Sorin Segall, P Eng
V.P., Technical Engineering

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

Education

1964 – 1968	University of Toronto Electrical Engineering Program (4 Year) Bachelor of Applied Science (B.A.Sc.) - Electrical Engineering – Graduated 1968
1959 – 1962	Ryerson Polytechnical Institute, Toronto, Ontario Engineering Technology Program (3 Year) "Diploma in Gas Technology" – Graduated 1962

Work Experience

1961	Union Gas Company, Brantford, Ontario Cathodic Protection Technician- May-Sept
1962	Corrosion Service Company Limited, Downsview, Ontario - Corrosion Technician 1968 – Staff Engineer 1971 – Manager of Engineering Department 1982 – Vice-President, Engineering 1993 – President, Correng Consulting Service Inc. (a wholly owned subsidiary of Corrosion Service Company Limited)
2001 (Jan)	Cathodic Protection Consultant through Correng
2004 (Aug)	Corrosion Service Company Limited - President and CEO
2006 (Mar)	Cathodic Protection Consultant via Correng Consulting Service Inc.
2014 (Mar)	Cathodic Protection Consultant via Corrosion Service Company Ltd

Awards

NACE International – Technical Achievement Award – 1989
NACE International – Technical Achievement Award – 1992
NACE International – R.A. Brannon Award – 2004
Appalachian Underground Cathodic Protection Short Course (AUSCPS) – 2013
Col. Charles C. Cox Award for Corrosion Engineering Contributions
NACE Fellows Award - 2016

Technical Association Memberships

- Association of Professional Engineers of Ontario (APEO)
  "Professional Engineer, P.Eng." – Since 1968
  Designated a Consulting Engineer in Corrosion in 1990

- National Association of Corrosion Engineers (NACE)
  Member # 02011-02 – Since 1963
  Accredited "Corrosion Specialist" #710 – Since 1972.

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Technical Association Memberships, *continued*

- NACE CP Teaching Activities
  - Qualified NACE Instructor – has taught NACE Cathodic Protection Courses over 100 times since 1978 including certification courses CP1, CP2, CP3, and CP4.
  - Co-author of the CP Theory and Data Interpretation Course - 1995
  - Principle author the CP3 course 'Cathodic Protection Technology"- 2003 - 2004.
  - Co-author of the CP Interference Course - 2004
- Member of the Editorial Advisory Board for NACE International Journal 'MP' – 2000
- Institute of Electrical and Electronic Engineers (IEEE) #6898936 : 1975-2001
- American Water Works Association (AWWA) #77660 : 1983-2001
- American Concrete Institute (ACI) #114059: 1989-2001

Technical Committee Participation

NACE Technical Practices Committee Activities

T-7-1 .... Corrosion of Municipal Water and Sewer Facilities – Chairman (1983–85)
T-7L.................. Cathodic Protection
T-7L-1 .... Cathodic Protection of Water Storage Tanks
T-7L-3 .... Cathodic Protection as it Relates to Grounding, Stray Current and Existing Safety Guidelines
T-7M................ Corrosion of Water and Sewage Treatment, Collection, and Distribution Systems – Past Chairman
TG35 (T-10A) .... Cathodic Protection
T-10A-11........... Gas Distribution Industry Corrosion Problems
T-10A-14........... Corrosion Control of Underground Storage Tank Systems
T-10A-21........... Corrosion Control of Ductile and Cast Iron Pipe
T-10A-22........... Electrical Continuity of Cathodically Protected Pipelines
T-10A-26........... Anode Test Methods
T- 10A-28.......... Cathodic Protection Criteria for Mortar Coated Pipelines
T-10B .... Interference Problems
T-10B-2............. Effects of High-Voltage Direct Current Transmission on Buried or Submerged Metallic Structures
T-10B-5............. Corrosion Control and Related Safety Procedures to Mitigate the Effects of Adjacent Alternating Current Power System
T-10C .... Electric Power and Communications
T-10C-2............. Effects of Electrical Grounding on Corrosion
T-10D-1 .... Coating Conductance Test Method -Chairman and Principle Author of Standard Test Method TM0102-2002 'Measurement of Protective Coating Electrical conductance on Underground Pipelines'

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Technical Committee Participation, *continued*

NACE Technical Practices Committee Activities (cont'd)

T-10-1 .... Review of RP-01-69 'Control of External Corrosion on Underground or Submerged Metallic Piping Systems'
TG285 .... Review of Criteria Section of RP0169- 2002
TG211 .... State-of-the-Art Report on the Application of the 100mV Shift Criterion – Chairman and Principle Author
T-11 .... Corrosion and Deterioration of the Infrastructure
T-11-1 .... Cathodic Protection of Steel in Concrete
T-11-1b .... Anode Test Procedures
T-11-1c .... Reference Electrodes for Use in Concrete
T-11-1d .... State-of-the-Art Report on the Criteria for Cathodic Protection of Pre-stressed Concrete Elements
T-11-1e .... State-of-the-Art Report on the Criteria for Sacrificial Cathodic Protection of Reinforced Concrete Elements
T-11-1f .... Recommended Practice on the Criteria for Cathodic Protection of Underground or Underwater Reinforced Concrete Elements
T-11-3a .... Organic Coatings for Steel Reinforcing Rod in Concrete
T-11-4a .... Corrosion Control Measures for Steel Reinforced Concrete
TG327 .... AC Corrosion – State of the Art Report on Corrosion Rate, Mechanism, and Mitigation Requirements-Vice Chairman -2007 to 2010
TG360 .... Review of RP0169-2007 'Control of External Corrosion on Underground or Submerged Metallic Piping Systems – 2007 to Present
TG 430 .... AC Corrosion on Cathodically Protected Pipelines: Standard Practice for Risk Assessment, Mitigation, and Monitoring -2011 to Present

AWWA

D104-91 .... Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks

CSA

S448.1 .... Repair of Reinforced Concrete in Buildings
CAN/CSA-S413-94 &
CAN/CSA-S413-04 .... Parking Structures Technical Committee – Structures Design

ULC

S603.1......... .... Standard for Galvanic Corrosion Protection Systems for Steel Underground Tanks

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General Papers & Presentations

- "An Alternative View of the Cathodic Protection Mechanism on Buried Pipelines", NACE Corrosion 2016, Vancouver, Mar 2016
- "Sir Humphrey Davy and Michael Faraday – The Original Corrosion & Cathodic Protection Pioneers", NACE International, 10,000 Lakes Pipeline Corrosion Control Seminar, Prior Lake, Minnesota, Feb, 2014
- "Cathodic Protection Myth–Conceptions", NACE International – 10,000 Lakes Pipeline Corrosion Control Seminar, Prior Lake, Minnesota, Feb, 2014.
- "An Alternative View of the Cathodic Protection Mechanism" NACE International – 10,000 Lakes Pipeline Corrosion Control Seminar, Prior Lake, Minnesota, Feb, 2014.
- "A Critical Review of an On-Potential Criterion" NACE International, Central Area Conference, Little Rock, Arkansas, August 27, 2013.
- "Would the Real -850mVcse Criterion Please Stand Up" NACE International Conference, Salt Lake City, Utah, Mar 2012, Paper #1347.
- Why are You Still Using Magnesium Anodes? Polish Cathodic Protection Conference, Jurata, Poland, Sept 2012.
- "The Questionable Performance of Magnesium Anodes", CGA Best Practice Conference, Winnipeg, MB, Oct 2011.
- "About Magnesium Anode Cathodic Protection and Its Performance, Enbridge Gas Corrosion Meeting, Whitby, ON, March 30, 2011.
- "Examining the Controversy Surrounding the -850mV CP Criteria", Pipeline & Gas Journal, Vol. # 237, No 11, November, 2010.
- "Cathodic (Polarization) Protection", NACE International Conference, San Antonio, TX. Presentation to Technical Exchange Committee TEG179, March 17, 2010.
- "AC Corrosion – a Tutorial", Banff Pipeline Workshop, Banff, Alberta, April, 2009
- "AC Corrosion & Cathodic Protection", NACE International Corrosion'08, New Orleans, TEG179X Committee on Cathodic Protection, March 20, 2008.
- "Interpretation of the E log I Criterion for Determining the Cathodic Protection "Current Requirements on Well Casings", NACE International, Northern Area Western Conference, Edmonton, Alberta, Feb 11-14, 2008.
- "Cathodic Protection Myth-Conceptions : Part 1", NACE International - Corcon' 07 Conference – Keynote Address, Mumbai India, Sept 26-28, 2007
- "Technical Considerations on the Use of the 100mV Cathodic Polarization Criterion", NACE International, Corrosion'07, Paper #7037, March 11-17, 2007.
- Cathodic Protection - Technological Changes and Application Challenges", A Plenary Lecture, 11th Middle East Corrosion Conference & Exhibition, Kingdom of Bahrain, Feb 26 – Mar. 1, 2006.
- "Sir Humphry Davy & Michael Faraday –The Original Corrosion & Cathodic Protection Pioneers", A Plenary Lecture, Australasian Corrosion Association Inc, Corrosion and Prevention 2005 Conference, Gold Coast, Queensland, Australia. Nov. 20-23, 2005.

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- "The Effect of Elevated Temperature on the Validity of the Cathodic Protection Criteria for Steel in Aqueous Environments – A Literature Review", NACE International, Northern Area, Eastern Conference, Halifax, N.S., Sept 11-14, 2005
- "Effect of Temperature on Cathodic Protection Criteria", Presentation to TEG179X at NACE International Corrosion '05, Houston, TX, April 3-8, 2005
- Prepared Chapters 1, 2, & 4 of the Cathodic Protection Interference Course for NACE International – June-Oct., 2004.
- Cathodic Protection Technology Course (CP3): Prepared 4 of the 5 chapters for this NACE International Certification Course, 2003-2004.
- "Sir Humphry Davy – Cathodic Protection Pioneer", NACE International, Alaska Section Meeting, Anchorage, AK, March 11, 2003.Cathodic Protection Myth - Conceptions – Presentation and Panel Discussion - NACE International- Northern Area -Western Conference, Edmonton, AB, Feb. 19, 2002.
- "Sir Humphry Davy – His Scientific Accomplishments", Toronto Cornish Association, Toronto, March 23, 2002.
- "Using Coupons and Probes to Determine the Level of Cathodic Protection", NACE Northern Area Western Conference & Exhibition - Proceedings, Victoria, BC, February 1998; NACE TechEdge Seminar, Denver, Colorado, Nov., 1997 and Materials Performance, Vol. 37, No. 8, August 1998, pp24-29.
- "A Perspective on the –100mV Potential Shift Criterion for Cathodic Protection of Steel", NACE International, Canadian Region Western Conference, Calgary, AB, Feb. 1994.
- "Cathodic Protection Potential Criterion For Underground Steel Structures", NACE Canadian Western Conference, Victoria, B.C., February 1993; NACE Corrosion '93, Paper No. 564, New Orleans, LA., March 1993 and Materials Performance, November 1993.
- "Investigating the Effect of Pulse Cathodic Protection Underneath a Disbonded Coating", R. Brousseau, S. Qian and R. Gummow; NACE Corrosion '93, Paper No. 2, New Orleans, LA, March 1993.
- "The Theory of Cathodic Protection and the Practical Measurement of Polarization", NACE Northeast Regional Conference, Buffalo, New York, October 1991.
- 'Cathodic Protection Design' - A cathodic protection design course prepared for the Technical University of Nova Scotia and presented in Feb. 1990 and Nov. 1990
- Cathodic Protection Criteria – A Literature Survey, Editor, NACE Publication, 1989.
- "Cathodic Protection Criteria - A Critical Review of NACE Standard RP-01-69", Materials Performance, September 1986.
- "Cathodic Disbondment - Fact or Mythology", NACE Canadian Region Western Conference, 1983.
- Preparation of "Power System Corrosion Manual", Canadian Electrical Association Project 091D188, 1982.
- "Interference - A Perspective", NACE Canadian Region Western Conference, February 1980.
- "Minimization of Cathodic Protection Stray Current in Congested Areas", NACE, Canadian Region

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Western Conference, February 1976.

- "Cathodic Protection of Underground Plant by the Flood Method", NACE Canadian Region Eastern Conference, Toronto 1972.

Pipelines

Papers & Presentations

- "Technical Considerations on the Use of the 100mV Cathodic Polarization Criterion" NACE International – 10.000 Lakes Pipeline Corrosion Control Seminar, Prior Lake, Minnesota, Feb,2014
- "Pipeline AC Mitigation Misconceptions" , NACE 2010 Northern Area, Western Conference, Calgary, Alberta, Feb 20, 2010
- "A New Approach to Cathodically Protecting Oil and Gas Transmission Piping Subjected to Induced Currents" Australasian Corrosion Association Conference, Wellington, NZ, Nov16-19, 2008.
- "Technical Considerations on the Use of the 100mV Cathodic Polarization Criterion", NACE Corrosion 2007, Nashville. TN, Paper #35, March 15, 2007
- "AC Corrosion on Cathodically Protected Pipelines and Its ECDA Implications" NACE International, Pipeline Integrity Direct Assessment Seminar, Houston, TX, Jan 11-12, 2006.
- "Results from an ECDA Plan", NACE International, Corrosion 2005, Houston, TX, April 3-8, 2005. (co-author and co-presenter).
- "Validation of the ECDA Process on Union Gas Pipelines in Southern Ontario", NACE International, Northern Area - Western Conference, Saskatoon, SW, Feb 15-17, 2005.(co-author and co-presenter)
- Case Histories of AC and Telluric Current Corrosion on Pipelines" Banff/2003 Pipeline Workshop, Banff, AB, April 14-17, 2003.
- "Telluric Current Effects on Underground Steel Pipelines" Effects of Space Weather on Technology Infrastructure (ESPRIT) Rhodes, Greece, Mar 25-29, 2003.
- "Cathodic Protection Current Requirements for Electrical Grounding Materials" NACE International – Northern Area – Western Conference, Calgary, AB, Feb 3-6, 2003.
- Preparation and presentation of a Seminar on AC Corrosion and Telluric Current Effects on Pipelines and their CP Systems, Williams Pipeline, Linden, NJ, Feb. 13, 2002 & Duke Energy, Harrisburg, PA, July 16, 2002.
- "Can Telluric Currents Cause Corrosion on Cathodically Protected Pipelines?" NACE International, Northern Area Eastern Regional Conference, Halifax, Nova Scotia, August 26-29, 2001.
- "Review of Cathodic Protection Codes & Standards", Banff Pipeline Workshop, Banff, April 9-12, 2001
- "CP Considerations for Pipelines with AC Mitigation Facilities", NACE International, Northern Area Conference, Toronto, Ontario, November, 2000".
- Telluric Current Effects on Corrosion and Corrosion Control Systems on Pipelines in Cold Climates", NACE International, Northern Area Western Regional Conference, Anchorage, AK, Feb. 26-28, 2001.
- "Electrical Interference on Underground Structures" prepared for EPIC corrosion control seminar, Toronto, Ontario, October, 2000.

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

- "Coating Quality Testing of Directionally Drilled Pipe Sections", NACE International, Northern Region Western Conference, Saskatoon, Saskatchewan, Feb. 2000 and NACE International, Corrosion 2000, Orlando, Florida, March 2000.
- "Evaluation of Telluric Current Effects on the Maritimes and Northeast Pipeline" Boteler, D.H., Gummow, R.A. and, Rix, B., NACE International Northern Area Eastern Conference, Ottawa, Oct. 1999.
- "GIC Effects on Pipeline Corrosion and Corrosion Control Systems", International Union of Radio Science – XXVIth General Assembly, Toronto, Ontario, Aug 1999.
- "AC Corrosion - A New Challenge to Pipeline Integrity, NACE Corrosion /98, Paper No. 566, San Diego, March 1998";
- AC Corrosion – A New Threat to Pipeline Integrity?", NACE Canadian Region Western Conference, February 1997; First International Pipeline Conference (IPC '96), American Society of Mechanical Engineers (ASME), Calgary, Alberta, June 1996. (co-authored by R.G. Wakelin and S.M. Segall)
- "Use of Polarization Cells on a Cathodically Protected Pipe Line located on a HVAC Corridor", NACE Canadian Region Eastern Conference, September 1977.
- "Cathodic Protection Design Considerations for Interprovincial Pipe Line - Sarnia to Montreal Extension", NACE Toronto Section, November 1976 and NACE Montreal Section, March 1977.

Pipeline Projects

- Advisor on PRCI research project to investigate cathodic protection current distribution on HDD pipeline installations in rock, 2015-2016
- Advisor on a long term AC Corrosion Field Research Project for TCPL, 2013-2016.
- Preparation of a Report entitled "Minimization of Errors in Cathodic Protection Measurements" for Enbridge, 2014-2015
- Technical Advisor on a Research Project to Investigate Cathodic Protection Shielding caused by Closed Cell Foam and 'PipePillo' supports for PipeSak Inc, Feb-June, 2014.
- CP Design for Large Diameter Pipeline inside a Micro Tunnel for the TCPL Tamaz Project in Mexico, June- Sept, 2013.
- Preparation of "AC Interference Guidelines" report for the Canadian Energy Pipeline Association (CEPA) 2012-13.
- Investigation into the Cause of a Corrosion Failure on an Aviation Fueling Pipeline for Shell Oil, 2012.
- Preparation of a report on Electrical Interference Identification and Mitigation for Pipelines for Pacific Gas and Electric Company, Walnut Creek, CA, Feb 2012
- Preparation of a report on the Cathodic Protection Investigation on Texas Eastern Gas Transmission Pipelines in the Vicinity of the Crossing of Buckeye/Lancer Pipeline near MP 129 between Route 850 and Ernest Rd, Landisburg, PA, Spectra Energy, Nov 2011.
- Preparation of 'An Interference Algorithm to Assess and Mitigate Stray Current Conditions on Cathodically Protected Pipelines' – Pacific Gas and Electric Company, CA, October 2011
- Preparation of ''AC Voltage Hazard Guidelines' – TransGas Limited, Regina, Saskatchewan –August

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

2011

- Preparation of a Document to Assist in Assessing an AC Voltage and Corrosion Hazard on a Pipeline for TransGas, SK, Nov-Dec, 2010 .
- Literature Review and Preparation of a Report on the Risk of Cathodic Disbondment and Hydrogen Embrittlement on Pipelines due to the Operation of Cathodic Protections Systems for Allied Corrosion and their client Spectra Energy, Aug 2009.
- Review of Cathodic Protection Design on the 16" Petroamazonas Panacocha Flow Line prepared for Engineering Universal Service EUS CIA, Ecuador, April, 2010.
- Design Review and Recommendations for Cathodic Protection of Ammonia and Naptha Gas Pipelines on the Ambatovy Project in Madagascar for SNC Lavalin, Jan-Mar, 2009.
- Investigation and Report on Potential Measurement Errors on Pipelines caused by DC Decoupling Devices used for Mitigating AC Voltages, Dairyland Electric, Aug-Sept. 2008.
- Consulting on Impact of a Hydrocarbon Leak on the Performance of a Cathodic Protection System at a Pipeline Crossing, Spectra Energy, Landisburg, PA, Sept-Nov., 2008.
- Consulting on Methods of Mitigating Induced AC on the 30" diameter Emera-NB Pipeline for Spectra Energy, Halifax, NS, Jan-Feb 2008,
- Preparation of a Cathodic Protection Data Analysis Algorithm for Evaluating Stray Current Effects on Pipelines for Pacific Gas & Electric, CA, August 2007.
- Investigation of Premature Corrosion Failure on 24" Bengal Pipeline in Louisiana and Subsequent Report for Shell Pipeline Inc, Houston, March, 2007.
- Preparation of CP Design Concept for 370 km, 30" diameter Waupisoo crude oil pipeline in Northern Alberta for Enbridge Pipeline (Athabasca Inc.) to counteract tellurric and AC interference, Fall 2006 - Spring 2007
- Consultant to Emera on Methods of Mitigating Induced AC effects on the Maritimes and Northeast Pipeline in Maine arising from the Construction of a 345KV Powerline, USA, 2004-2005.
- Review of ECDA program and results on several pipeline projects in Southern Ontario for Union Gas, 2004-2005.
- Evaluated the grounding system and CP facilities at Compressor Station 1301 for TransCanada Transmission, April, 2002.
- Reviewed the CP Design on the Islander East Gas Transmission Pipeline crossing of Long Island Sound for Duke Energy, 2002.
- Reviewed CP Design on Phase 3 and the Boston Harbour Crossing of the 30" dia. Maritimes & Northeast Gas Transmission Pipeline for Duke Energy, 2002
- Produced CP Design Concept for the protection of SS Filter Screens and nearby Steel Cooling Water Piping at a Nitrogen Plant in Atasta, Campeche, Mexico, for Compania de Nitrogenia de Canterell, 2002
- Reviewed ICA-Fluor Daniel CP design for the Internal Surfaces of the Cooling Water piping at a Nitrogen Plant in Atasta, Campeche, Mexico, for Compania de Nitrogenia de Canterell, 2001-2002.
- Investigated causes of Corrosion Failures on Cooling Water Piping at a Nitrogen Plant in Atasta, Campeche, Mexico, for Compania de Nitrogeno de Canterell, 2001.

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

- Produced CP Design Concept for the protection of SS Filter Screens and nearby Steel Cooling Water Piping at a Nitrogen Plant in Atasta, Campeche, Mexico, for Compania de Nitrogenia de Canterell, 2002
- Conducted a 'Cathodic Protection System Gap Analysis' for PRC International, GRI Research Contract # 8294, 2001-2002.
- Managed a 'Permanent Reference Electrode Testing Program' for PRC International, Research Contract # 262-0031, 2000-2005.
- Consulted on the Design of an Internal Cathodic Protection System for a Sea Water Cooling Piping Network at the Cantarell Nitrogen Plant, Mexico for Compania de Nitrogeno de Cantarell (CNC), 2000-2001.
- Managed research contract regarding 'Telluric and Ocean Current Effects on Buried Pipelines and their Cathodic Protection Systems' for PRC International, Research Contract #262-0030, 2000-2001.
- Managed a research project to determine the effect of the attachment of ground rods on the cathodic protection of pipelines at pipeline stations for PRC International, Corrosion Supervisory Committee - PR-262-9913 - March 1999 - July 2001
- Audit of company Cathodic Protection Standards and Procedures and preparation of recommendations with regard to current industry practice and latest technology for Sask Energy, Saskatchewan, Oct.-Dec. 1999.
- Project Manager for the cathodic protection design, installation, and commissioning for the on-shore gas pipeline facilities of the Sable Offshore Energy Project, Goldboro to Point Tupper, Nova Scotia, 1999-2000.
- Prepared conceptual design for Telluric Current Mitigation Facilities for Maritimes and Northeast Pipeline 30" mainline from Goldboro, N.S. to the New Brunswick /Maine border, May-November, 1998.
- Conducted research project on Cathodic Protection Considerations for Pipelines with AC Mitigation Facilities for PRC International - Corrosion Supervisory Committee, American Gas Association, PR-262-9809, March 1998 - November 1998.
- Managed a research project that evaluated and developed methods of testing Coating Quality on Directionally Bored Piping for PRC International, Corrosion Supervisory Committee, American Gas Association, PR-262-9738, June 1997-October 1999.
- Completed a literature investigation on AC corrosion on cathodically protected pipelines for TNPL, IPL, SPPL and SCPL group of pipeline companies, 1995
- Completed an Evaluation of Corporate Cathodic Protection Testing Procedures and Practices for Union Gas and Centra Gas in order to recommend which Standard Procedures should be adopted in the integrated Company-1997.
- Prepared a corrosion control manual for natural gas transmission and distribution piping for CNG Transmission Corporation, WV – 1994 - 1995.
- Project manager for the preparation of an AC Mitigation design on the 20" Ø Panhandle Gas Transmission Line for Union Gas Limited, Chatham, Ontario - 1993.
- Managed a research project that investigated the protection effect of zinc ribbon cathodic protection in the presence of simulated telluric current, Alyeska Pipeline Service Co. – 1994.

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

- Project manager for the optimization, through computer modelling, of the cathodic protection system on the 12" Ø Sarnia-to-Waterdown Oil Products Pipeline – Sarnia Products Pipeline, 1993.
- Review of cathodic protection test data and test procedures at coupon test stations for Alyeska Pipeline Service Co. for the period of Mar. 1993 to Mar. 1994
- Reviewing cathodic protection testing facilities included in field test loop for Alyeska Pipeline Service Co., 1992.
- Design of AC fault grounding system for Union Gas and TransCanada Pipe Line facilities at Kirkwall Transfer Station, 1992.
- Expert Witness concerning coating and cathodic protection effectiveness on the Trans-Alaska Pipeline system for Steptoe & Johnson, on behalf of Alyeska Pipeline Service Company vs. State of Alaska during rate hearings in Washington, D.C. – 1991.
- Project Manager for a research project into methods of enhancing corrosion control underneath disbonded coatings conducted by the National Research Council for the Alyeska Pipeline Service Company - Nov. 1990 - Oct. 1991.
- Design of AC Mitigation System and Cathodic Protection Facilities for Union Gas - St. Clair River / Bickford 24" diameter Pipeline - 1988.
- Revision of Maintenance and Operating Procedures for pipelines subjected to Induced AC for Union Gas - 1988.
- Design of AC Mitigation system and cathodic protection system for 24" dia. high pressure Kirkwall gas pipeline for Union Gas Ltd. - 1988.
- Directed computer optimization of the cathodic protection system design on the proposed 1700 km, 56" diameter natural gas pipeline for Foothill's Pipelines (1981 - 1982).
- Prepared "Specifications for the Mitigation of Induced AC Voltage Effects" for TransCanada Pipelines, (1979).
- Prepared report on "Induced Voltage Mitigation Considerations" for the Gas East Pipeline Project (1979).
- Attended NEB hearing on TransCanada Pipe Lines Gas East Pipeline Project as an expert witness on induced AC voltages on pipelines (1
- Involved in design and field mitigation procedures for induced AC voltage problem on Interprovincial Pipeline 26 mile Nanticoke Lateral (1978).
- Design of all cathodic protection facilities (mainline and pumping stations) for Interprovincial Pipeline 520 mile, 30" diameter Sarnia-to-Montreal extension (1976-1977).
- Responsible for cathodic protection design, maintenance, and operation for Interprovincial Pipeline facilities in Eastern Canada (1975 to 1985)

Steel Reinforced Concrete

Papers & Presentations

- "Performance Evaluation of Conductive Coating Cathodic Protection Systems for Reinforced Concrete Structures" NACE International – Western Area Conference, Tigard, Oregon, Oct 1-3, 2001

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

- "Evaluating the Performance of Conductive Coating Cathodic Protection Systems Applied to Reinforced Concrete Parking Decks", NACE Canadian Eastern Regional Conference, Toronto, Ontario, November 1991.
- "Selection and Performance Evaluation of Cathodic Protection Systems for Reinforced Concrete Parking Structures", Construction Repair International, Vol. 3, No. 5, June 1989.
- "Reinforcing Steel Corrosion Mechanisms", National Reinforced Concrete Cathodic Protection Association (NRCCPA) Seminar - May 1989.
- "Rebar Corrosion Control" Construction Canada Magazine, Vol. 30, No. 2, March 1988.
- "Cathodic Protection of Reinforced Concrete Structures", Association of Civil Engineers, Halifax, November 1985.

Projects

- Evaluation of Corrosion Control Measures with regard to Specification Compliance for Underground Structures at the Proposed TTC Sheppard Ave Maintenance Facility for AECOM, 2013.
- Consulting on Corrosion Control Measures for the Ashbridge's Bay TTC Electrical Transit System Storage Yard for AECOM, 2011-12.
- Consulting to CSCL on Reinforcing Steel Potential Measurement Anomolies and Discrepancies between Surface Placed Reference Electrodes and Embedded Coupon/Reference Probes on the Manulife Parking Garage Cathodic Protection System, Toronto, Jan 2010.
- Preparation of a report on Corrosion & Corrosion Control Considerations for Reinforced Concrete Structures for Yolles Partnership Inc with respect to the post-tensioned Dundas St. Parkade, Toronto, July, 2003.
- Project Manager for the supply of CP Inspection & Testing Services on the Burlington Skyway Pier Rehabilitation Project – MTO Contract 99-25, Aug.-Dec. 1999.
- Development and Testing of a multi-element probe to assess corrosion activity in reinforced concrete structures – 1997-1998.
- Design of a sacrificial cathodic protection system for a 3,500 sq. meter reinforced concrete floor at 125 Scadding Ave, Toronto for Read-Jones Christoffersen Consultants, 1997.
- Assessment of corrosion activity on the reinforcing steel in the transit vehicle ramps of the TTC St. Clair W. Station for Yolles Partnership Ltd., Nov./Dec. 1992.
- Consultant to Consultants en Recherches Appliquées des Materiaux (CRAM) on a research investigation on CP Criteria for reinforcing steel in concrete for Energy, Mines and Resources Canada (CANMET) – 1989.
- Consultant to Robert Halsall and Associates on a contract from the Canadian Mortgage and Housing Corporation (CHMC) to produce a state-of-the-art report on the CP of reinforced concrete parking structures and to prepare a draft standard for CSA.-1989.
- Consultant to Battelle Columbus on SHRP 87-C102B - Cathodic Protection of Concrete Bridges a $1.9 million research program to identify and test the most feasible CP systems for both reinforced concrete decks and substructures. 1988 to 1990.
- Engineering advisor on cathodic protection Feasibility Study for the construction joints on MTUC Subway Tunnels (1987).

- Supervision of cathodic protection test results involving various aspects of applying cathodic protection to reinforcing steel in concrete (1987 - present).

Municipal Infrastructure

Papers & Presentations

- "Performance Efficiency of High Potential Magnesium Anodes for Cathodically Protecting Iron Watermains", NACE International Northern Area Eastern Conference, Ottawa, ON, Sept 14-17, 2003; NACE International Northern Area Western Conference, Victoria, BC, Feb. 17-18, 2004; Materials Performance, May, 2004, pp28-33.
- Corrosion Control of Iron & Steel Water Piping – A Historical Perspective, NACE International Northern Area – Eastern Conference, Quebec City, Aug 26-27, 2002.
- "Corrosion Control of Municipal Infrastructure using Cathodic Protection", NACE International Northern Area Eastern Conference-Ottawa, Oct., 1999.
- "The Effect of Copper on the Corrosion of Iron Watermains", NACE Corrosion 90, Las Vegas, Nevada, April 1990 – R.G. Wakelin and R.A. Gummow.
- "Experiences with Watermain Corrosion - Cathodic Protection Could Save $1M per Km", Environmental Science and Engineering, Vol. 2, No. 3, June 1989.
- "Experiences with Watermain Corrosion", Joint Annual Conference of the Ontario Section AWWA and the OMWA, London, May 1988.
- "The Corrosion of Municipal Iron Watermains", Materials Performance, Mar. 1984.
- "Corrosion and Cathodic Protection of Underground Metallic Water Piping Systems", NACE Canadian Region Eastern Conference, October 1978 and AWWA Ontario Conference, May 1979.

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

Municipal Infrastructure Projects

- Consulted on the Cathodic Protection Testing and Design for Aluminum Sewage Treatment Tanks for Corix, Vancouver, 2012.
- Investigation of the Cause and Mitigation on the Corrosion of Copper Water Service Piping for Magnum Property Management, Cambridge, Ontario, 2012.
- Expert Witness on the Cathodic Protection Effectiveness on Steel Water Pipelines with Disbonded Coal Tar Enamel Coatings for Whitelaw Twining Law Corporation for the Greater Vancouver Water District(GVWD) vs NAPS trial, May-June, 2010.
- Report on Pipeline Replacement Strategies on Watermains for the City of Toronto, June, 2010.
- Expert Witness on the Cathodic Protection Effectiveness on Steel Water Pipelines with Disbonded Coal Tar Enamel Coatings for Whitelaw Twining Law Corporation for the Greater Vancouver Water District(GVWD) vs. NAPS trial, May-June,2010.
- Preparation of a Report on the Impact of Stray Current from Electric Transit System Operation on the Corrosion of Cast Iron Piping and Copper Water Service Piping and Recommendations for Remediation for the City of Toronto, Jun, 2009.
- Prepared a Report on Polyethylene Tape Coatings for Steel Water Pipelines – for Northwest Pipe Company, April, 2004.
- Consultant for the CP design, testing and monitoring on the 36" / 60" Ø Pockwock Prestressed Concrete Cylinder Water Transmission Main for the Halifax Water Commission, 1989 to 1998.
- Prepared a Report on Polyethylene Tape Coatings for Steel Water Pipelines – for Northwest Pipe Company, April, 2004.
- Consultant for the CP design, testing and monitoring on the 36" / 60" Ø Pockwock – RCP Water Transmission Main for the Halifax Water Commission, 1989 to 1999
- Consultant to various municipal consultants on 'NEEDS' studies for corrosion evaluation and mitigation on existing water distribution systems as follows:

Year	Municipality	Consultant
1989	Clifford	Gamsby & Mannerow
	Peterborough	Proctor & Redfern
	Kingson	Proctor & Redfern
	Owen Sound	Simcoe Engineering
	Wallaceburg	Gore & Storrie Ltd.
1988	Ottawa/Carleton	Cumming Cockburn Ltd.
	Trenton	Thorburn Penny
1987	Cornwall	Simcoe Engineering

- Project engineer for the cathodic protection system (DICCAP) for existing iron watermains (1984 - 1985)

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

Petrochemical

Papers & Presentations

- "Review of the Hybrid Galvanic CP Systems for STI-P3 Underground Storage Tanks", Steel Tank Institute Technical Committee Meeting, Chicago, Nov. 2, 2003.
- "CP Criteria for Underground Steel Storage Tanks", Steel Tank Institute, General Meeting, Niagara Falls, ON, Aug. 3, 2003.
- "Analysis of CP Performance Using Zinc Anodes Internally on Underground Storage Tanks" Steel Tank Institute, General Meeting, Niagara Falls, ON, Aug. 2, 2003.
- "Corrosion Control of Underground and Aboveground Storage Tanks", Canadian Institute Seminar, Toronto, ON, Nov. 1996, May 1992.
- "Corrosion Control for Surface Storage Tanks", Symposium Beton-en Staalonderhoud, Betonvereniging (Netherlands Concrete Society), Holland, May 1996.
- "Cathodic Protection Tester's Course for Underground Storage Tanks Protected in Accordance with CAN/ULC-S603.1-92 Standard" - A cathodic protection tester's course prepared for The Steel Tank Association of Canada (STAC) and NACE Toronto Section and presented in Waterloo and Toronto, ON, Apr. 1996.
- "Cathodic Protection Corrosion Control of Storage Well Casings", Cavern Operators Seminar, Sarnia, November 16, 1988.
- "Corrosion Control of Flat Bottom Storage Tanks", NACE Section Meeting, Sarnia, Ontario, November 15, 1988.
- "Corrosion Control Methods for Underground Storage Tanks", Technical University of Nova Scotia, Storage Tank Seminar, Halifax, Nova Scotia, August 23-24, 1988.
- "Corrosion of Underground Storage Tanks and Piping Systems", Technical University of Nova Scotia, Storage Tank Seminar, Halifax, Nova Scotia, August 23-24, 1988.
- "Cathodic and Anodic Protection Applications in the Petrochemical Industry", Ontario Research Foundation Corrosion Seminar - Sarnia, Ontario, June 7, 1988.

Petrochemical Projects

- Technical Advisor for the Design of a Cathodic Protection System for the West Qurna Oil Field, Exxon Mobil, Basra, Iraq, Nov 2013 – Feb 2015.
- Design Review and Recommendations on the Cathodic Protection of Storage Tank Bottoms at the Kharg Island Tank Farm of the National Iranian Oil Company for PSN corrosion control Services, Feb-Jun, 2009.
- Conducted an in-house Research Project on the Effectiveness of Various Impressed Current Anodes for the Cathodic Protection of Aboveground Storage Tank bottom Plates, Mar 2007 – Mar 2008, IRAP #
- Reviewed Cathodic Protection Design for Oily Water Filtration Vessels for Torr Canada Inc for the Kuwait Oil Co Upgrade Facility Reviewed, May-June,

- Cathodic Protection Performance Data for the Bottom External Surfaces of Crude Oil Storage Tanks at the Valdez Terminal, Alaska, for Alyeska Pipeline Service Company, November, 2003.
- Prepared a cathodic protection testers course on Underground Storage Tanks for the Canadian Region of NACE – 1994/95.
- Developed and prepared specifications for a national standard on the cathodic protection of underground fuel storage tankage for the Petroleum Association for the Conservation of the Canadian Environment (PACE) in 1978 and 1987 revision.

Marine Projects

- Peer review of CP Design for sheet pile dock structure in Cook Inlet, Anchorage, AK, for Coffman Engineering, Spring 2007.
- Conducted a Research Project on the Feasibility of Cathodically Protecting Steel Off-Shore Pipeline Joints having Sea Foam Sleeves, Duke Energy, Hubline Project, June 2003 to March 2004.
- Sr. Design Engineer for the cathodic protection of the steel ice shields on the reinforced concrete piers of the Confederation bridge between New Brunswick and Prince Edward Island for J. Muller International • Stanley Joint Venture Inc., 1994-1995.
- Field study into long-term performance of Al/In alloy anodes on a steel structure in seawater for Canada Metals, Mar./Apr. 1993.
- Senior Project Manager for the cathodic protection design on the Hibernia Gravity Based Structure for Newfoundland Offshore Development Constructors, St. John’s, Newfoundland, 1991-1993.

Miscellaneous Projects

- Managed a Stray Current Interference Investigation on the Copper Grounding Cable for a Solar Farm in Brockville, Ontario, Canadian Solar, 2012.
- Investigation and Report on Corrosion Susceptibility and Service Life of Galvanized Steel Support Posts for First Solar, NJ, Dec, 2010.
- Preparation of a Design and Operating Manual for the Cathodic Protection of SS316L Stainless Steel Frames in an Effluent Stream for Trojan UV Project in Hawaii, Oct-Nov, 2009.
- Corrosion Investigation Report and Preparation of a Cathodic Protection Design for Aluminum Oven Pans Holding High Chloride Water at 100C for Proctor and Gamble Limited(P&G), Belleville, Ontario, Oct-Nov, 2009 and Feb 2010..
- Review of a Report on Variable Cathodic Protection Criteria for South West Research Institute (SWRI) before submittal to the Pipeline Research Council International(PRCI), Jan, 2009
- Corrosion Inspection and Preparation of a Cathodic Protection Design for Carbon Steel Filter Tanks at GE Ground Water Treatment Facility, Lansdowne Ave, Toronto for Gartner Lee Environmental Consultants, October 2007.
- A Literature Review on the Corrosion Susceptibility of a SS303/Red Brass Couple in Potable Water for Canadian Pipeline Accessories (1986) Corporation, Langely, BC, Dece
- Evaluation of corrosion activity on ferrous structures at the Pt. Aconi Generating Station of NSPC

CORROSION SERVICE

ROBERT A. GUMMOW, P.ENG.
Corrosion Specialist

for Sargent & Lundy Engineers, Dec. 1992 - Feb. 1993.

- Investigation into the cause of corrosion on steel wall studs at the Bendale Acres seniors residence in Scarborough for Construction Control Ltd. and Ellis Don Contractors, Sept. /Oct. 1992.
- Preparation of a Power System Corrosion Manual for the Canadian Electrical Association (1982 - 1983).

Legal Work

- Attended NEB hearing on TransCanada Pipe Lines Gas East Pipeline Project as an expert witness on induced AC voltages on pipelines (1979).
- Expert Witness concerning coating and cathodic protection effectiveness on the Trans-Alaska Pipeline system for Steptoe & Johnson, on behalf of Alyeska Pipeline Service Company vs. State of Alaska during rate hearings in Washington, D.C. – 1991.
- Expert Witness concerning implications on cathodic protection effectiveness on a steel water pipeline having a disbonded coating for Whitelaw Twining Law Corporation, Vancouver, on behalf of the Greater Vancouver Water District (GVWD) vs. NAPS, May-June,2010.
- Preparation of a report on a cathodic protection interference investigation on Texas Eastern Gas Transmission Pipelines in the vicinity of the crossing of Buckeye/Lancer Pipeline near MP 129 between Route 850 and Ernest Rd, Landisburg, PA, for Saul Ewing LLP, Harrisburg, Pennsylvania, on behalf of Spectra Energy, Nov 2011.
- Investigation into the possibility that dc stray current interference was the cause of a corrosion failure on an aviation fuel pipeline for Carita Shanklin Walker, Houston, on behalf of Shell Oil, 2012.
- Expert Witness concerning a corrosion failure on a sulfuric acid storage tank bottom having a cathodic protection system for Amall Golden Gregory , Atlanta, on behalf of Southern States Chemical - 2013
- Expert witness for King Spalding with regard to pending litigation on behalf of Atlanta Gas Limited (AGL) involving possibility of stray current interference corrosion on new gas main -2014-2015
- Expert witness for LCY Corporation of Taiwan pertaining to the corrosion failure of a 4” diameter propylene pipeline in 2014-Present

<u>UNION GAS LIMITED</u>

Answers to Interrogatories from
<u>Board Staff</u>

1. Ref: Application and Evidence / p. 3

Preamble:

Letters of indemnity were signed in November and December 2015 to confirm the volumes that each customer has accepted. The letters of indemnity will form the basis of the contracts to be signed with the customers. Contracts are expected to be signed by February 29, 2016. If any customers do not sign a contract a third proration exercise will be completed.

Questions:

a) Please confirm that the contracts have been signed as expected. If not, please provide details regarding the outcome of the third proration exercise and advise whether customers have signed contracts for their revised capacity assignments.

b) Please advise whether any customers opted to make an aid to construct payment.

c) Please provide a range for: (i) the duration of the contracts signed; and (ii) the contracted MAV (if applicable).

Responses:

a) As of April 8, all contracts and Letters of Agreement have been fully executed - 52 long term contracts and 3 Letters of Agreements.

These agreements account for all 51,900 m3/hour of firm capacity that the project will create.

b) After completing customer negotiations, 3 customers are required to pay an aid to construct. The aid amounts range from $11,180 to $118,820.

c)

Duration of Contracts Signed (years)	Range of MAV (annual m3)
2	2,630,630
3	964,368 – 2,350,656
4	912,788 – 8,500,000
5	1,091,680 – 10,000,000
6	974,740 – 8,500,000
7	1,297,160 – 4,407,924
8	1,303,536 – 6,850,000
9	2,215,880 – 11,576,000
10	2,620,600 – 7,530,134