Consultant Report

MPLA - NEB Abandonment Cost Estimates Hearing - MH-1-2012

Prepared for

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Prepared by

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1.0 - Background

On 29 June, 2012, Mr. John Goudy (Scott Petrie, LLP, London, Ontario, Canada) contacted Mr. James Bushman [Bushman & Associates, Inc., (B&A), Medina, OH, USA] and retained the latter as an expert witness to prepare a report for Scott Petrie, LLP, a London-Ontario-based law firm who is representing the Manitoba Pipeline Landowners Association (MPLA, Manitoba, Canada). The purpose of the report, which will be filed with the National Energy Board (NEB, Canada) is to (a) review the issues related to the Enbridge Pipelines, Inc., (Enbridge) approval application and (b) to provide an opinion as to the reasonableness of the Enbridge physical plans for abandonment.

The NEB, which regulates federal pipelines that cross provincial and national borders, is considering applications from a number of pipeline companies for approval of preliminary abandonment cost estimates. The NEB has the authority to order pipeline companies regulated under its jurisdiction to begin collection of funds in advance to cover the future costs of pipeline abandonment. MPLA is a voluntary organization consisting of agricultural landowners along the Enbridge mainline through Manitoba. Some MPLA landowners have seven or more liquid lines running through their properties. MPLA has chosen to participate as an intervenor in the hearing process in order to have input into the NEB's consideration of the pipeline abandonment cost estimates put forward by Enbridge. Both the NEB and MPLA landowners subscribe to the fundamental principle that the landowners are not to be responsible or liable for the costs of pipeline abandonment by Enbridge or other pipeline companies.

The Canadian Association of Energy and Pipeline Landowner Associations (CAEPLA), of which MPLA is a member, petitioned the NEB in 2008 that the abandonment cost funding should be based on the assumption that all medium (14 to 24-inch) and large (26-inch or greater) diameter pipelines will be removed from the land upon abandonment. CAEPLA argued that this conservative approach was necessary in order to ensure that the landowners would not be responsible in the future for costs and liabilities associated with the abandoned pipelines. The NEB declined CAEPLA's conservative approach, but instead proposed the base case assumptions whereby 20% of medium and large diameter pipelines would be removed on abandonment and the remaining 80% would be maintained in perpetuity. The NEB has since revised its base case assumptions and confirmed that the pipeline companies may seek to justify departures from the base case for individual pipeline-specific reasons.

In preparing this report, B&A has reviewed, in detail, sixty-one documents provided by Scott Petrie concerning the aforementioned subject matter (list of the documents reviewed is attached in Appendix A). B&A opinions expressed in this report are based on the information which we reviewed in these documents and the 80+ man-years of experience and expertise in the corrosion and corrosion-control field of which at least 1/2 is directly related to corrosion and corrosion control of buried steel pipelines. The CVs of the Expert Witness, Mr. James B. Bushman, P.E., and B&A's Principal Researcher, Dr. Bopinder Phull, are attached to this report in Appendix B.

2.0 – Enbridge Pipeline Abandonment Assumptions

What Enbridge is proposing to do with respect to pipelines that they wish to abandon essentially follows the recommendations of the Canadian Energy Pipeline Association (CEPA) report.

The Canadian Energy Pipeline Association Report (Sep 2006 - Apr 2007) states that land use is the most important factor used to determine abandonment strategies and that a risk-based, comprehensive specific site assessment is needed to validate the chosen abandonment strategy for specific pipelines. While a combination of abandonment methods is likely for large projects, the most common issues include (NEB) regulatory requirements, environmental considerations, land use, ground subsidence, remediation, pipe cleanliness, water crossings, erosion, water conduits, rail, road or utility crossings, and post-abandonment responsibilities.

The report defines the pipe sizes as follows based on outside diameter ranges:

- Small (2 to 12 inches)
- Medium (14 to 24 inches)
- Large (26 inches and greater)

The report reiterates that the most important consideration for any pipeline abandonment/removal project is the existing and potential land use. It describes three primary abandonment options:

- A: Abandon pipeline in place
- A+: Abandon pipeline in place but with special treatment to prevent potential ground subsidence (e.g. fill pipe with concrete)
- R: Remove pipeline

The report states the following key assumptions from the 1996 PASC Discussion Paper on Technical and Environmental Issues to be still relevant and applicable:

- Pipe abandoned in place shall be emptied of service fluids, purged or appropriately cleaned or both; physically separated from any in-service piping; and capped, plugged, or otherwise effectively sealed.
- Pipe can be cleaned to an acceptable level (applicable regulatory standard).
- External pipe coatings are stable (environmental) and acceptable to remain in place.
- Assessment of potential environmental effects.

The CEPA report recommends abandonment in place for the following land uses because disturbance caused by pipe removal will adversely affect sensitive areas or existing infrastructure: environmentally sensitive areas (e.g. parks, wetlands, at-risk habitats), water crossings, non-agricultural lands (e.g. forests, commercial, industrial, residential), non-cultivated lands (e.g. prairie, rangeland), roads and railways, cultivated land. It recommends removal of pipe for the following land uses because of the pipe becoming a hindrance to on-going land management activities: prospective future development (e.g. commercial, industrial, residential), cultivated land with special features where depth of cover is of concern (e.g. tree farms, turf farms, deep-tilling operations).

With regard to ground subsidence, the report states that for pipelines with diameters of 12 inches or less even the worst conditions of structural collapse would cause negligible ground subsidence. For larger pipe diameters it says that studies commissioned on corrosion observed less than 1% of the pipeline length would contain coating defects where corrosion could occur; concluding that such pipelines would retain structural integrity for decades, if not centuries. The abandonment matrix assumes that cathodic protection (CP) will be discontinued in all cases. Concerning the potential for abandoned in-place pipe becoming a conduit for water movement, the report states that the abandoned pipe would be segmented at appropriate locations.

2.1 - Pipeline Abandonment Report by P. J. Teevens and D. W. Robertson, 14 May 2008

The main conclusions of the Teevens and Robertson report are: (i) removal of abandoned large diameter pipelines would alleviate future contamination and cathodic protection (CP) concerns, but there could be other issues related to soil contamination (weeds) and soil subsidence in single and multiple pipeline corridors (ROW, Right-of-Ways), (ii) corrosion deterioration is metal wastage, a form of "pollution generation", (iii) did not support automatic removal of pipelines upon abandonment; instead, recommended change in regulations such that a legacy maintenance fund could be created for dispositioning of the subject pipelines by all future stakeholders, (iv) unless there is reasonable prospect for future use, remove large diameter abandoned single or all pipelines in a common corridor, (v) maintain CP on all abandoned pipelines to minimize external corrosion, (vi) thoroughly clean all abandoned pipelines that are not removed and apply "green" corrosion inhibitor to minimize internal corrosion, (vii) monitor all in-place abandoned pipelines (10-inch diameter or greater) periodically for corrosion damage, (viii) possible important uses for abandoned pipelines in the future (e.g. conveyance of alternative fuels, fresh water, data communications) if risk of post-abandonment liabilities and costs for landowners can be eliminated at the time of abandonment.

3.1 – Review of Pipeline Abandonment Impacts

3.1.1 - Corrosion, Cathodic Protection and Coatings: B&A generally concurs with the conclusion in the Teevens and Robertson report that removal of abandoned pipe would eliminate future contamination and cathodic protection (CP) concerns. Pipelines transporting oil/gas are made of steel. Without appropriate corrosion control, steel must corrode. For buried pipelines, corrosion rates depend on many factors, e.g. soil moisture content, pH, dissolved salts, dissolved gases, temperature, stray current activity, induced alternating currents (AC) from high-voltage overhead power transmission lines, telluric currents due to magnetic induction by sunspot activity, from certain types of bacteria that can accelerate corrosion (MIC - Microbiologically Influenced Corrosion), the quality and condition of the coating (or lack thereof) and dissimilar metal couples. In underground service, steel pipelines are now typically protected externally using a combination of coatings and cathodic protection (CP). For regulated pipelines (and related underground or underwater facilities), CP is a requirement. CP is an electrochemical method that involves the application of an external direct current (DC) to the structure to be protected. With proper application, maintenance and monitoring, CP is the only technique that can completely stop corrosion.

Coatings are also widely used for corrosion control. The primary function of a coating is to act as a barrier between the metal structure and a corrosive environment. However, coatings have holidays or develop pin holes and can deteriorate in service. It is well understood and accepted that corrosion rates at coating defects are almost always significantly increased on buried and submerged structures. Therefore, they cannot provide 100% protection indefinitely without inspection, repair or replacement. In underground service, coating repair/replacement is impossible without excavation. Nowadays it is common practice to use CP in conjunction with coatings because the two complement each other. In other words, a well applied coating reduces the CP current required for protection very significantly and enhances current distribution (i.e. better "spread" of protection); conversely, CP increases the life of the coating appreciably. For best practice, the coating must be properly bonded to the pipe surface and CP status monitored and the system maintained to assure that full protection is being achieved (e.g. per NACE Standard SP0169).

3.1.2 - Coating Failure and Localized Corrosion: Although many pipelines were constructed in the 1940s, there is no experience with long-term abandonment in place. Coatings do not have an indefinite life span. For a coating to perform optimally during its life span, it must be properly bonded to the pipe surface. In service, any areas of coating disbondment from the pipe surface can create problems. Water and bacteria will enter such areas and initiate localized corrosion unless sufficient CP current reaches those areas to prevent corrosion. Certain types of coatings (e.g. tape wrap) can shield CP current from the pipe surface where the coating has disbonded. It is highly significant that this phenomenon was identified by the Transportation Safety Board of Canada as the root cause failure of the Enbridge's crude oil pipeline near Binbrook, Ontario, on 29 September, 2001. Thus, it is highly probable that such failures would also occur in abandoned in-place pipelines even with CP, especially as the coating deteriorates/disbonds with time. Even if a coating does not disbond from the steel surface, the coating will become more permeable with time, requiring more CP current to maintain protection. In any case, the components delivering the CP current do eventually need replacement and the CP system would also need upgrading. The tasks associated with CP system maintenance, monitoring, replacements/upgrading in perpetuity are not trivial and should not be underestimated.

If the CP current is shielded from the steel surface by at coating disbondment areas, or if the CP system is not maintained, pitting corrosion will occur. The pit penetration rate will depend on the local soil characteristics and the amount of coating disbondment that exists.

The Transportation Safety Board of Canada Pipeline Investigation Report P01H0049 described in detail a corrosion failure on Line 10 at Mile Post 1885.64, near Binbrook, Ontario. This pipe failed due to corrosion under a disbonded polyethylene tape coating. The report stated on page 6 in item 3 that "*In 1990, the corrosion defect at MP 1885.64 was probably 40 to 45 per cent through wall but was not identified in the 1990 in-line inspection (ILI) vendor's final report and was therefore not repaired at the time."* The report continued in item 4 with *"During the subsequent 11 years, corrosion continued until the wall had thinned to 16 per cent of its original thickness and the pipe wall could no longer support the stresses associated with the internal operating pressure."*

If the pipe wall was originally 0.250" thick, the pipe wall was reduced by corrosion to between 0.138" and 0.150" thickness. 11 years later, this thickness had been reduced by further corrosion to 0.040" thickness which calculates to a corrosion rate of .009" to .010" per year. These are very high corrosion rates (9 to 10 mils/year) indicating how severe the corrosion activity can be on disbonded polyethylene tape coated pipelines. Typically, in my experience, corrosion rates on buried steel pipelines are in the range of 0.5 mils to 3 mils per year. Worse yet, this report clearly confirms that cathodic protection is totally ineffective in preventing corrosion under these deteriorated coating systems.

In an unpressurized pipeline, pitting corrosion will eventually perforate the pipe wall thickness, allowing intrusion of ground water, micro-organisms and other debris into the pipe interior. Any contaminants that might be present in the soil from previous pipeline leaks or other activities could then be transported through the pipe conduit to downstream locations, emerging at other perforated pipe areas and consequently spreading any pollutants even further from the "source". The only way to assure against this scenario would be to perform comprehensive soil testing at the time that the pipeline is abandoned in place. To preclude a similar situation on the pipe interior, the pipeline would have to be completely cleaned during abandonment.

3.1.3 - Internal Corrosion: Even if the steel is fully protected by CP on the pipe exterior surface, corrosion on the pipe interior wall would still be an issue. Purging with an inert gas or utilizing a volatile corrosion inhibitor (VCI) would certainly reduce the corrosion rate markedly, but any anaerobic bacteria present on the interior could accelerate corrosion - even under these conditions. Thus, pipe wall perforation on in-place abandoned pipelines would occur from the exterior and/or interior. Once the pipe wall is breached, the inert gas or VCI would leak out; the pipe would act as a water conduit for potable, storm and waste water and corrosion accelerated by ingress of corrodents from the soil side.

3.1.4 - Multiple Pipelines: Where multiple pipelines run in a common corridor, it is even more imperative that an in-place abandoned pipeline be maintained to the same or higher degree as an individual in-place abandoned pipelined at a more remote location. Not maintaining and monitoring CP on an abandoned pipeline in a common corridor could present problems for the other, still operating, pipelines, e.g., due to shielding of CP current distribution and/or accidental electrical shorting leading to underprotection of the operating pipelines. Abandoned pipelines in common corridors should be removed, especially if they are known to have disbonded coatings because of the problem of shielding of CP current discussed earlier, for example, for the Enbridge pipeline failure at Binbrook, Ontario, in 2001. This site also experienced extremely high corrosion rates under the disbonded coated.

3.1.5 - Pipe Collapse and Inert Material Fill Usage: Eventually, an in-place abandoned large diameter pipeline, unless fully maintained, is expected to corrode through to the point that the soil overburden will lead to collapse, resulting in ground subsidence and potential public-safety consequences. Enbridge proposes to segment the pipeline into sections (of unspecified length) and fill it with concrete to avoid this situation. Unfortunately, this represents a very small portion of the entire pipeline to be abandoned. We estimate the filled segments to be less than 2% of the abandoned pipeline if the average plug is assumed to be 30 meters in length and there will be, on the average, a plug every 2.5 km as estimated by Enbridge. Any future projects that require deep soil removal would be complicated significantly by the need to cut, lift and remove pipeline sections made inordinately heavy by the concrete fill.

At road and railroad crossings, any ground subsidence is not typically acceptable. At such locations, the pipe sections would appropriately be left in place, having been filled with a suitable, inert and structurally sound material (e.g. concrete).

3.1.6 - Contamination: If the pipeline abandoned in place acts as a water conduit, there is no doubt that contaminants from the soil (e.g. from pipeline leaks and spills during its construction and operational history) will be transported to other locations downstream other leaks locations on the pipeline. This would not get rid of any environmental problems associated with such contaminates but simply "transfer" them from one location to another. This may be one of the more important issues if pipelines are abandoned in place.

3.1.6.1 - Land Re-Sale Value: It is very likely that the re-sale value of land adjacent to and over in-place abandoned pipelines (especially ones that carried liquid petroleum products in service) will be substantially lowered because of the potential hazards described previously and interference of the pipeline with the new owner’s plans. In the USA, banks will simply not loan money to a real-estate purchaser or real-estate commercial developer without extensive environmental-impact testing to assure that a nearby petroleum pipeline has not contaminated the environment associated with the subject land. It is often found that comprehensive testing discloses previously undiscovered contaminates. In such situations, the affected soil has to be removed and the site cleaned up and the pipeline or other source structure removed before the property could be sold. The principal investigator for this report has served as an expert witness in a number of civil cases where small leaks in pipelines as well as underground petroleum storage tanks have gone undetected for years resulting in substantial contamination of both soil and potable ground water supplies.

4.0 General Conclusions

From the landowner's viewpoint, the best situation would be to have the pipeline completely removed at the time of abandonment; and the land restored to its original condition. Unless the pipeline is removed, adequate funds must be set aside for the sole purpose of all future adverse consequences which could affect the landowner. If the companies are held responsible for in-place abandoned pipelines indefinitely by the NEB, then removal after abandonment would appear to be the best option for the companies, too; because of future costs and liabilities for them are unpredictable, but this is only true if they are absolutely held accountable regardless of mergers, bankruptcies, assets-only based sales, etc.

CEPA's position, adopted by Enbridge, that disturbance caused by pipe removal would adversely affect environmentally sensitive areas in indefensible. There is a compelling counter argument, i.e. the same factors were (or should have been) considered when the pipelines were installed or upgraded. As discussed earlier, in-place abandoned pipe will be subject to perforation eventually and then act as a water conduit which has its own adverse consequences. The removal of the pipe is likely to be less harmful in the long term than pipe abandonment in place and its attendant consequences.

The main reason for not wanting to remove an abandoned pipeline may well be the real fear that many contaminated sites will be discovered and, once found, will have to be remediated as required by current environmental regulations.

5.0 - Summary

In Summary, Enbridge's Physical Plan for Abandonment is, in our opinion, both technically incorrect and unreasonable for the following reasons:

> (a) Eventually, all in-place abandoned steel pipelines will fail. Unless fully protected, external and internal corrosion will ultimately lead to pipe wall perforation.
>
> (b) Except where it is not physically possible, all abandoned pipelines should be removed to prevent them acting as water conduits and potentially spreading contaminates in the soil (i.e., from previous leaks and spills) from one location to another after they become perforated, e.g. by corrosion. This is the most important argument for removing the pipelines if there are no firm future plans to use them. Removal of the pipeline will also minimize any future risk, e.g., liability for landowners, ground subsidence due to pipe collapse, or insufficient funds being available for remediation of any problems.
>
> (c) It appears to us that the pipeline companies do not want to remove all abandoned pipelines because this option would locate previously unidentified contaminated area and appropriate remediation to restore the land according to current provincial and federal regulations would then be required.
>
> (d) If a pipeline is abandoned in place, metal loss due to corrosion will eventually weaken the pipe wall to the point that the pipe will collapse and, in the case of large diameter pipelines, cause soil subsidence - with its consequences such as affecting public safety and land usage.

(e) Abandoned pipelines should be removed, especially if they are known to have disbonded coatings, because CP is ineffective at such areas. In other words, areas shielded from CP current will incur pitting and in time perforate, allowing ingress of ground water and contaminates and their transport downstream. Further, disbonded coatings generally significantly accelerate corrosion.

(f) Abandoned pipelines should also be removed from common corridors (multiple lines) because they can interfere with the CP of operational pipelines. Any contamination from an in-place abandoned pipeline that perforates will be transported downstream by the pipe acting as a water conduit.

(f) In the long-term, environmental effects on sensitive areas resulting from in-place pipeline abandonment could be substantially worse than those associated with pipe removal.

Respectfully submitted by:

James B. Bushman, P.E., C.P.S., S.C.T.
Principal Corrosion Engineer

Appendix “A”

B&A List of Reviewed Documents

MPLA - NEB Abandonment
Cost Estimates Hearing - MH-1-2012

APPENDIX "A"

LIST OF DOCUMENTS REVIEWED BY JAMES B. BUSHMAN July 25, 2012

No.	DATE	DOCUMENT
1.	2009 05 00	NEB Decision re LMCI Stream 3 (Pipeline Abandonment – Financial Issues) https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=802858&objAction=Open
2.	2009 12 17	NEB Preliminary Base Case Assumptions https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=587345&objAction=Open
3.	2009 12 17	NEB Preliminary Base Case Table https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=587351&objAction=Open
4.	2010 03 04	NEB Revised Base Case Assumptions https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=802854&objAction=Open
5.	2012 02 10	NEB Hearing Order MH-001-2012 (Cost Abandonment Estimates) https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=789351&objAction=Open
6.	2012 03 27	MPLA Application for Intervenor Status in MH-001-2012 https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=804336&objAction=Open
7.	2012 05 01	NEB Letter Decision re Scope of Proceeding https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=813266&objAction=Open
8.	1985 09 00	NEB Report on Negative Salvage Value https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=542931&objAction=Open
9.	1986 02 19	NEB Letter to Companies re Negative Salvage Value https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473148&objAction=Open
10.	1996 11 00	Pipeline Abandonment Steering Committee – Pipeline Abandonment: A Discussion Paper on Technical and Environmental Issues https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=543360&objAction=Open
11.	1995 07 17	H.R. Heffler Consulting Ltd. and TERA Environmental Consultants (Alta.) Ltd. – Environmental Issues Concerning Pipeline Abandonment
12.	1996 01 26	Biophilia Inc. – Identification and Assessment of Trace Contaminants Associated with Oil and Gas Pipelines Abandoned in Place https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473142&objAction=Open
13.	1995 05 12	Corrpro Canada, Inc. – Pipeline Corrosion Evaluation
14.	1996 04 00	Geo-Engineering (M.S.T.) Ltd. – Geotechnical Aspects of Terrain Subsidence after Pipeline Abandonment
15.	1995 11 02	Trans-Northern Pipelines Inc. – Letter re Ottawa Lateral Abandonment https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473217&objAction=Open
16.	1996 01 29	Montreal Pipe Line Limited – Letter re Abandonment of 12" line https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473205&objAction=Open

17.	1996 07 00	NEB Reasons for Decision – MH-1-96 – Manito Pipelines Ltd. Application to Abandon Pipeline http://publications.gc.ca/collections/Collection/NE22-1-1996-12E.pdf
18.	1997 05 00	Pipeline Abandonment Legal Working Group – Legal Issues Relating to Pipeline Abandonment: A Discussion Paper https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=543363&objAction=Open
19.	2006 08 11	Legal Memorandum to Ultramar Ltd. re Pipeline Abandonment Issues http://www.bape.gouv.qc.ca/sections/mandats/pipeline_st_laurent/documents/DA49.pdf
20.	2007 02 12	Oil and Gas Journal – Decommissioning-1: NEB case study shows abandonment pitfalls https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473145&objAction=Open
21.	2007 02 26	Oil and Gas Journal – Decommissioning-2: Past contamination, future land use set abandonment time line https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473199&objAction=Open
22.	2007 03 05	Oil and Gas Journal – Decommissioning-Conclusion: Regulators must possess early risk-assessment understanding https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=473202&objAction=Open
23.	2007 10 03	NEB Letter introducing Land Matters Consultation Initiative (LMCI) https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=501171&objAction=Open
24.	2008 03 00	NEB LMCI Stream 3: Financial Issues Related to Pipeline Abandonment – Discussion Paper https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=501392&objAction=Open
25.	2008 02 28	NEB LMCI Stream 4: Physical Issues of Retirement and Reclamation – Discussion Paper https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=501271&objAction=Open
26.	2008 05 20	CAPLA Response to NEB LMCI Stream 3 and 4 Discussion Papers https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=514537&objAction=Open
27.	2008 05 14	Broadsword Corrosion Engineering Paper Submitted to NEB on behalf of CAPLA – Pipeline Abandonment – Pipeline Corrosion-Related Technical Issues and Long-Term Landowner Impacts https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=514798&objAction=Open
28.	2008 11 05	CAPLA Second Evidence Filing https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=538709&objAction=Open
29.	2008 12 17	CAPLA Reply Evidence https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=542928&objAction=Open
30.	2008 00 00	NEB Filing Manual Requirements - Guide B – Abandonment https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=543366&objAction=Open
31.	2004 04 27	Enbridge Application to NEB for Leave to Abandon MP 54 Mainline Pipeline (abandonment in place) https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=543369&objAction=Open
32.	2004 09 03	Enbridge Revised Application to NEB for Leave to Abandon MP 54 Mainline Pipeline (removal) https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=543372&objAction=Open

No.	DATE	DOCUMENT
33.	2011 05 25	Letter to NEB – Abandonment Physical Plans https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=689762&objAction=Open
34.	2011 05 25	Appendix A – System Map https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=689765&objAction=Open
35.	2011 05 25	Appendix B – Eastern Region Pipeline Schematic https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=689768&objAction=Open
36.	2011 04 29	Appendix C – Stantec Consulting Ltd. Report https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=689771&objAction=Open
37.	2006 09 00	Appendix D – Canadian Energy Pipeline Association (CEPA) – Pipeline Abandonment Assumptions – Technical and Environmental Considerations for Development of Pipeline Abandonment Strategies (Draft) https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=689774&objAction=Open
38.	2011 11 29	Application for Approval of Abandonment Costs – Preliminary Estimate https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=765957&objAction=Open
39.	2011 11 29	Appendix A – Revised Tables 2a, 2b and 2c and Stantec Report https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=765960&objAction=Open
40.	2011 11 29	Appendix C – Enbridge Inc. Stakeholder Workshop (Edmonton) https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=766076&objAction=Open
41.	2011 11 29	Appendix D – Enbridge Inc. Stakeholder Workshop (Montreal) https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=765935&objAction=Open
42.	2011 11 29	Appendix G – Enbridge version of NEB Table A-3 – Unit Costs for Abandonment Activities https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=765969&objAction=Open
43.	2011 11 29	Appendix H – Enbridge version of NEB Table A-4 – Cost Estimate by Pipeline Diameter Category (by Line) and by Terminal https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=765938&objAction=Open
44.	2012 03 19	Enbridge Response to NEB Information Request 1 https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=801158&objAction=Open
45.	2012 03 19	Attachment to Enbridge Response to NEB IR 1.4 – Pipeline Removal Scope Table https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=800940&objAction=Open
46.	2012 04 27	Enbridge Response to NEB Information Request 2 https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=812145&objAction=Open
47.	2012 06 01	MPLA Information Request 1 to Enbridge https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=822016&objAction=Open

48.	2012 04 16	Letter of Comment to NEB from Canadian Agricultural Safety Association https://www.neb-one.gc.ca/ll-eng/Livelink.exe?func=ll&objId=814771&objAction=Open
49.	2009 10 16	CEPA – Final Report – Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods http://www.cepa.com/wp-content/uploads/2011/06/Pipeline-Surface-Loading-Screening-Process-2009.pdf
50.	2010 12 00	NEB – Guidance for Safe Crossings of NEB-Regulated Pipelines Using Agricultural Vehicles and Mobile Equipment https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=659461&objAction=Open
51.	2011 12 08	PCB Regulations SOR/2008-273 (Canada) http://laws-lois.justice.gc.ca/PDF/SOR-2008-273.pdf
52.	2009 06 00	Canadian Association of Petroleum Producers (CAPP) – Best Management Practice – Mitigation of External Corrosion on Buried Pipeline Systems http://www.capp.ca/getdoc.aspx?DocId=155642&DT=PDF
53.	2011 06 00	NEB – Regulating Pipeline Abandonment http://www.neb-one.gc.ca/clf-nsi/rthnb/pblcprtcptn/lndmttrs/strm4/pplnbndnmnt/pplnbndnmnt-eng.pdf
54.	2011 12 20	North American Oil & Gas Pipelines Article – Can you afford the risk? – Taking Care of Contaminated or Abandoned Pipelines – John K. Buckert http://www.napipelines.com/featured/2011/2011-11-feature-3.html
55.	1998 00 00	Hinwood and Denis – Environmental Issues in Pipeline Facility Abandonment
56.	2011 10 28	NEB LMCI Stream 4 – Pipeline Abandonment Physical Issues Committee – Key Abandonment Issues Summary http://www.neb-one.gc.ca/clf-nsi/rthnb/pblcprtcptn/lndmttrs/strm4/mnt/trkybndnmntsss-eng.html
57.	Undated	State of Louisiana – Powerpoint Presentation re feasibility of using abandoned pipelines in Coastal Louisiana
58.	2010 11 00	Det Norske Veritas – Pipeline Abandonment Scoping Study prepared for NEB http://www.teraenv.com/_pdf/Pipeline%20Abandonment%20FINAL%20REPORT%20Jan%206.pdf
59.	1996 02 27	TSB report re Interprovincial Pipe Line Inc. Glenavon Rupture – *Pipeline Investigation Report, TSB of Canada, 02 27 1996*
60.	2001 09 29	TSB report re Enbridge Binbrook spill - *Pipeline Investigation Report, TSB of Canada, 29 Sep 2001*
61.	2012 07 12	NofM to compel answers - *Motion by MPLA to NEB in matter of Enbridge pipeline abandonment Hearing Order MH-1-2012 and Group 1 abandonment cost estimates*

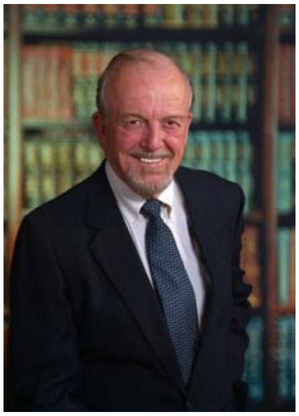
Appendix "B"

B&A Expert Resumes

MPLA - NEB Abandonment
Cost Estimates Hearing - MH-1-2012

BUSHMAN & Associates, Inc.
CORROSION CONSULTANTS
P.O. Box 425, Medina, OH 44258 • Phone 330/769-3694, Fax 330/769-2197

Resume of James B. Bushman, P.E., C.P.S., S.C.T.



Employment:
Years Employed by B&A: 17
Total Years of Corrosion Engineering Experience: 47

Education:
Case Institute of Technology, Cleveland, OH
General Motors Institute of Technology, Flint Michigan

- Major Industrial Engineering

Professional Registrations and Licenses Currently in Effect

- Professional Engineer (Corrosion / California / 1977 / N0. 512)
- NACE International Certified Cathodic Protection Specialist and Senior Corrosion Technologist (1973/1991, No. 1619)

Professional Society Activities

- NACE International Member – 1968 to date – Current Program Coordinator and Previous Assistant Program Coordinator for Specific Technology Groups STG 01 Reinforced Concrete, STG 02 Coating and Linings – Atmospheric, STG 03 Coatings and Linings – Immersion and Buried Service, STG 04 Coatings and Linings - Surface Preparation and STG 043 Transportation – Land. In addition, is Current Member of Technology Exchange Groups 016X, 024X, 043X (Current Vice Chair), 102X, 179X, 262X, 053X and 338X, Task Groups 011, 013, 017, 019, 044, 045, 047, 048, 049, 054, 055, 167, 169, 264, 290, 321 & 324
- Chairman of 1994 NACE National Convention Symposium – "Corrosion and Corrosion Control of Steel Reinforced Concrete Structures"
- American Society for Testing & Materials (ASTM) – 1992 to date – Active member of the G-1 (Corrosion) and the E-50 (Environmental) Committees including serving as Chair of the E-50 Committee (1993 – 1996) which developed the original standard on "Evaluating UST's prior to Upgrading", and Secretary of the Follow-Up Committee G-1-10 Task Group, which prepared the current standard (1996 – 1999).
- American Water Works Association - Chairman of the Cathodic Protection Task Force (1965 – 1975), and member of Underground Corrosion Task Force.
- Accredited NACE Instructor, 1975 – 1985
- SSPC – The Society for Protective Coating – Member since 1996

Professional Experience:

Principal Corrosion Engineer, Bushman Associates. Mr. Bushman interfaces with numerous clients with respect to research, development of new concepts and technology, applicable for detection and evaluation of corrosion and corrosion control technologies. During his 47 year career, he has held a number of different positions in what was then the world's largest Corrosion Control Firms including member of the Board of Directors (1983 – 1992), Senior Vice President 1981 – 1992, Manager of Research and Development (1975 – 1992), Manager of European Operations (1978 – 1992), Manager of Concrete Services Group for 1978 – 1992), Northeast US Area Manager (1968 – 1972), Manager of Water and Waste Water Corrosion Control Operations (1964 – 1968) and US & International Marketing Manager (1972 – 1991). In 1992, he left to found Bushman & Associates as an independent consulting engineering firm. His commitment was to operate as an independent corrosion research and engineering consultant with no ties to manufacturers or suppliers of corrosion control materials or systems.

He has provided both general corrosion engineering services, performing research and development studies in corrosion and corrosion control for a wide variety of structures as well as expert witness services where appropriate for buried and submerged metallic structures including:

Buried Fuel Storage Tanks	Above Ground Fuel Storage Tanks	P.O.L. Pipelines
Natural Gas Pipelines	Offshore Production & Drilling Platforms	Ship Hulls & Submarines
Water & Wastewater Piping	Steel Reinforced Concrete (SRC) Bridges	SRC Piers, Docks & Wharf's
Pipe Type Power Cable	Lead Sheathed Telephone Cable	SRC Parking Garages
Traveling Screens	Nuclear Reactor Containment Shells	Cooling Towers
Elect. Power Gen. Plants	Steel & Cast Iron Tunnel Liners	Sub-sea Oil & Gas Pipelines
Cable Stay Bridges	Water & Wastewater Treatment Units	Coating Performance Testing
Building Foundations	Lead Based Paint Removal/Replacement	Building Structural Steel

In addition to his fundamental corrosion control development work on many of the above structures and his 24 patents, some of his most notable research and project management efforts include:

- Project Principal Engineer for the first computer based close interval surveys including both "On" and "Instant-Off" potential measurements to determine cathodic protection system effectiveness on underground pipelines in Europe (British Gas for 7 of their 12 divisions – 1976)
- Project Principal Engineer for the first Telluric Current compensated close interval surveys performed anywhere in the world (British Gas – East Midland division – 1977)
- Project Principal Engineer for the first close interval surveys performed on subsea pipelines at depths to 800' and lengths over 200 miles (North Sea – Total Oil – Aberdeen, Scotland – 1979)
- Project Co-Principal Researcher – Corrosion and cathodic protection of steel reinforced concrete and structures (F.H.W.A. Turner-Fairbanks Research Center, McClean, VA (1976/1983).
- Corporate Co-Principal Research Director – Underground Storage Tanks (UST's) working with various state and federal agencies including the U.S. Environmental Protection Agency in developing new standards for and methods of achieving more effective corrosion control on underground fuel storage tanks (1968/1983).
- Project Principal Engineer – Develop galvanic anode design approach and engineering application methodology to facilitate use of single cavity molds to cast multiple length and cross section aluminum and zinc anodes for use in applying cathodic protection to subsea pipelines, docks, piers and platforms (Dow Chemical Company in association with Federated Metals – 1975/1983).
- Co-Project Engineer – Analyze and test alternative galvanic aluminum alloy anode materials for use in sub-sea muds containing various chloride levels and at different temperatures both in the Gulf of Mexico and North Sea (Dow Chemical Company and Phillips Petroleum – 1976/1978)
- Research, Field Model and Develop Anode Resistance Formula for various slab shaped galvanic anodes used to provide Cathodic Protection for submerged metal structures (US Army Construction Engineering Research Laboratories – 2005)
- Develop systematic Cathodic Protection System Design Manuals for various structures both at military bases and civil works facilities (US Army Construction Engineering Research Laboratories – 2001)

Awards:

- One of only two persons to be recognized by the U.S.. Secretary of Transportation as an Expert in Cathodic Protection.
- Recipient of the 1994 Colonel George C. Cox Award for Individual Public Contribution to the Science of Underground Corrosion and Control awarded at the 39th Annual Appalachian Underground Corrosion Short Course, University of West Virginia.
- Recipient of the 1992 Charles W. Sonnenberg Award for Technical Contributions on Corrosion and Corrosion Control for Steel Underground Storage Tanks, Steel Tank Institute, Lake Zurich, IL
- Recipient of numerous certificates of appreciation from the U.S.. Air Force, U.S. Army, NACE, AWWA, and the Steel Plate Fabricator's Association.
- Only Corrosion Engineer selected to serve on the Federal Highway Administration's Technical Work Group to implement the Transferring of Technology from their Strategic Highway Research Program to their operating Federal and State Highway Agencies.

Patents:

- Inventor or Co-Inventor, 24 U.S. Patents

Publications:

- "Field Application of Performance Enhancing Chemicals to Metallized Zinc Anodes"
- "Statistical Analysis of Soil Characteristics to Predict Mean Time to Corrosion Failure of Underground Metallic Structures"
- "Cathodic Protection of Underground Storage Tanks"
- "Calculation of Corrosion Rate from Corrosion Current (Faraday's Law)"
- "Corrosion and Cathodic Protection Theory"
- "Cathodic Protection of Underground Storage Tanks"
- "Corrosion and Cathodic Protection for Steel Reinforced Concrete Bridge, Garage and Marine Substructure Support Members"
- "Fundamentals of Electricity"
- "Galvanic Anode Cathodic Protection System Design"
- "Maintenance of Cathodic Protection Systems"
- "Financial Impact of Corrosion on the Economy"
- "Technical Review of 100 mV Polarization Shift Criterion for Reinforcing Steel in Concrete"
- "Liner Polarization, Potentio-Static & Potentio-Dynamic Electrochemical Corrosion Rate Testing in the Laboratory and in the Field"
- "Impressed Current Cathodic Protection System Design"
- "Cathodic Protection of Water Storage Tanks"
- "Computers for Corrosion Engineering Testing and Information Management"
- "IR Drop in Cathodic Protection Measurements"
- "Cathodic Protection for Traveling Screens"
- "Interpretation of Potential Measurements of Cathodically Protected Sub-sea Pipelines"
- "Corrosion and Cathodic Protection of Steel Reinforced Concrete Bridge Decks"
- "Corrosion Protection Systems for Bridge Stay Cables and Anchorage's"
- "Evaluating the Performance of the Electro-Osmotic Pulse Basement Dewatering System"
- "Lessons Learned from Ductile and Cast Iron Pipe, Volumes I, II, & III"
- "Chapter 64 – Highways, Bridges & Tunnels" of ASTM Textbook
- "A New Awareness of Copper Pipe Failures in Water Distribution Systems" – Co-Author
- "Copper Pipe Failure by Microbiologically Influenced Corrosion"
- "Evaluating the Performance of the Electro-Osmotic Pulse Basement Dewatering System"
- "Ice Free Cathodic Protection Systems for Elevated Water Storage Tank in Cold Climates"
- "Wireless Technologies for Remote Monitoring of Cathodic Protection"
- "Practical Applications of Cathodic Protection for Corrosion Control of USTs"
- "Ice Free Cathodic Protection for Water Storage Tanks"

Textbooks and Courses:

- Course and Textbook entitled "Corrosion and Cathodic Protection for Steel Reinforced Concrete Bridge Decks" together with preparation of student notebooks and experiments followed by instruction on behalf of the Federal Highway Administration of over thirty (32 hours each) courses for state highway agencies at various locations throughout the United States.
- Course Preparation with multiple presentations on "Corrosion and Corrosion Control for Gas Distribution Companies" including over 2000 slides and 30 "hands"-on experiments for both in-house and outside personnel training for Northern Illinois Gas Company, Chicago, IL
- Develop Course Textbook and Instruct over 30 2-Day Courses throughout the U.S. on "Corrosion and Corrosion Control for Steel Underground Storage Tanks and Piping", Steel Tank Institute, Lake Zurich, IL
- Co-Author Course Textbook with Michael Szeliga and Debra Simpson with multiple presentations on "Corrosion and Corrosion Control for Steel Reinforced Concrete Pressure Pipe", American Concrete Pressure Pipe Association, Reston, VA
- "Cathodic Protection Rectifier Handbook"
- "Marine Corrosion in Tropical Environments", Co-Editor with Sheldon W. Dean and Guillermo Hernandez-Duque Delgadillo, published by the American Society for Testing and Materials, ASTM Stock Number STP1399
- "Guide Manual - Selection, design, installation, operation, and maintenance of cathodic protection systems (CPSs) for navigation lock gates and other civil works hydraulic structures", James B. Bushman for the US Army Corps of Engineers Construction Engineering Research Laboratories, Champaign, IL

Guest lecturer on Corrosion and Corrosion Control --
(Total of more than 3000 lectures running from 1 Hour to 2 Weeks in length) for the following:

UNIVERSITIES

- University of West Virginia, Morgantown, WV
- University of Wisconsin, Madison, WI
- Purdue University, West Lafayette, IN
- Worcester Polytechnic Institute, Boston, MA
- California State Polytechnic Institute, Pomona, CA
- Iowa State University, Ames, IA

UNITED STATES GOVERNMENT

- Training Safety Institute, U.S.. Department of Transportation, Oklahoma City, OK
- Federal Highway Administration, Washington, DC
- Federal Office of Underground Storage Tanks, Washington, DC
- Air Force Institute of Technology, Dayton, OH
- Strategic Air Command, United States Air Force, various locations in the United States
- Civil Engineering Research Laboratories, U.S. Army Corps of Engineers, Champaign, IL
- Kennedy Space Center, NASA., Cape Kennedy, FL

PRIVATELY SPONSORED FEE PAID SEMINARS

- More than 500 — 1 to 3 day Seminars at various locations in the United States, Canada, United Kingdom, and the Netherlands sponsored by various clients and companies

NACE SPONSORED LECTURES AND SEMINARS

- NACE Course No. 2 Lecturer at various locations in the United States, Kuwait, and Iran. (Note: Each complete course was taught for 4 1/2 days in the U.S.. and 9 1/2 days overseas with a minimum of 7 hours of lecture per day.)
- Presentation of over 300 lectures on a diversity of Corrosion and Cathodic Protection subjects at various NACE Seminars, Regional, and National meetings in the U.S.., Mexico, and the United Kingdom.

Partial list of lecture topics presented since 2000:

- "Fundamentals of Corrosion and Cathodic Protection for Steel Reinforced Concrete Structures"
- "Computer Controlled Electrochemical Corrosion Testing Methodologies including Linear Polarization, Galvanostatic, Potentiodynamic, E-LogI, Cyclic Polarization and Polarization Resistance Scanning Methods"
- "Mechanism and Impact of Corrosion on Steel Reinforcing in Concrete"
- "Economic Analysis of Alternative Corrosion Control Methods for Steel Reinforced Concrete Bridges and Parking Structures"
- "PC Computer Software & Hardware – What is the latest, greatest and best for your use?"
- "Corrosion Control Methods for Underground Pipelines"
- "Design of Galvanic Cathodic Protection for Underground Pipelines"
- "Electrolyte Resistivity Measuring Techniques"
- "Anode Selection Options for Underground Storage Tanks"
- "Generation of Telluric Earth Currents by Solar Flare (Sunspot) Activity and their Impact of Corrosion Measurements and Control"
- "Basic Electricity"
- "Corrosion Control Methods"
- "Design of Galvanic Anode Systems"
- "Coating Systems for Underground Storage Tanks"
- "Computers and Technology"
- "Linear and Non-Linear Polarization Measurement Techniques for Analyzing Corrosion and Corrosion Control Criteria"
- "Analysis and Selection of Alternative Criteria for Cathodic Protection"
- "Cathodic Protection of Water Storage Tanks - How do you know it is working?"
- "Use of Computers for Cathodic Protection Measurements and Analysis"
- "Statistical Procedures including Multi-variant Linear Regression Analysis and Analysis of Variance to Evaluate Measurable Values Impacting Corrosion of Ferrous Metals in Various Electrolytes"
- "Corrosion and Cathodic Protection of Underground Steel Water Pipelines and Aqueducts"
- "Selection, Design and Successful Implementation of Deep Anode Beds for Cathodic Protection"
- "Cathodic Protection of Water Treatment Clarifiers and Flocculators"
- "IR Drop Error in Cathodic Protection Potential Measurements"
- "Cathodic Protection Alternatives for Ship Channel Lock and Dam Structures"
- "The What and Why of the Controversy Over NACE Recommended Practice RP-01-69, Corrosion Control for Buried and Submerged Metallic Pipelines"
- "Anode Beds, Which, When and Where"
- "Cathodic Protection of Marine Structures – Issues and Answers"

Partial list of additional significant corrosion engineering projects:

General Representative Corrosion Engineering Projects

Principal Corrosion Consultant – National Academy of Science/Transportation Research Board Panel on Corrosion in the Soil Environment, NCHRP Project 21-06, Washington, DC

Principal Consultant — Evaluation of Interior Corrosion Attack and Develop Recommendation including Design for Corrosion Control on 6 Above Grade Type 316 Stainless Steel Alloy Chemical Storage Tanks, Catalytic Corporation, North Carolina containing two different electrolytes using Liner Polarization and Tafel (ElogI) Potentiodynamic Corrosion Rate Analysis Systems.

Expert Witness — Evaluate Corrosion Attack Mechanism and Probability of Failure Mode of Above Grade Storage Tanks containing Acid Contaminated Solvents, Boston, MA. Client Name and Location Confidential

Principal Corrosion Value Engineer – Member of Value Engineering Team responsible for Detailed Review and Prepare Alternative Recommendations for Corrosion Control on proposed Lake Hodges Reclaimed Water High Pressure Transmission Pipeline, City of San Diego Metropolitan Waste Water District, CA.

Expert Witness — Evaluate Mode of Failure of Interior Coating System in Cathodically Protected Steel Water Storage Tank and Provide Recommendations for Design Changes in System Design to Prevent Similar Failures in the Future, Eidson Steel Products, Albuquerque, NM

Principal Corrosion Value Engineer – Member of Value Engineering Team responsible for Detailed Review and Prepare Alternative Recommendations for Corrosion Control on existing and new Water Transmission Pipelines, Miramar Road Area, City of San Diego Metropolitan Water District, CA.

Principal Investigator – Perform Laboratory Corrosion Pitting and Rate Analysis on 316L Stainless Steel in Contact with Elevated Temperature Spent Solvent using Computer Controlled Potentio-Dynamic and Linear Polarization Measurements and Develop Corrosion Control Program based on Data Obtained, Catalytica Pharmaceuticals, Inc., Raleigh, NC

Principal Engineer — Evaluation of Corrosion Conditions and Preparation of Plans & Specifications for Installing Cathodic Protection on Multiple On-Grade Heating Oil Storage Tanks, Seymour Johnson Air Force Base, NC

Principal Engineer – Evaluation of Alternative Anode Materials and Development of Selection Criteria for Use in Cathodic Protection Systems, Cathodic Protection Management, Inc., Hoffman Estates, IL

Principal Engineer — Investigate Characteristics, Extent, Impact and Remediation Methods for Geo-magnetically Induced Stray Currents (Telluric Currents) on Natural Gas Transmission Lines in England and Scotland, British Gas Corporation, Great Britain

Principal Consultant — Investigate Corrosion Control Systems, Methodologies, Practices and Effectiveness on 20,000 Mile High Pressure Gas Transmission and Storage System including Development of Recommended Changes to Improve Mitigation Effectiveness, Natural Gas Pipeline Corporation of America, Lombard, IL

Principal Consultant – Development Detailed Specifications for Cathodic Protection of Alternative Water Transmission Pipeline Systems in Florida, CPM, Inc., Hoffman Estates, IL

Principal Corrosion Value Engineer – Member of Value Engineering Team responsible for Detailed Review and Prepare Alternative Recommendations for Corrosion Control on proposed new Water Transmission Pipeline and Tunneling Project, Miramar Early Start Project, City of San Diego Metropolitan Water District, CA.

Expert Witness — Corrosion Control System Failure Analysis of Flexible Carbon Based Anode System in Steel Reinforced Concrete Structure, Twin Cities Fire Insurance Companies, San Francisco, CA

Principal Instructor — Program No. 6980 – Flammable Liquid Storage Tank Systems Management, College of Engineering, University of Wisconsin, Madison, WI

Principal Consultant – Measuring Corrosion Control System Effectiveness including Analysis of Stray DC Currents using Computerized Automatic Data Logging System, Gridley Lock & Dam, Port of Boston, Massachusetts, CPM, Inc., Hoffman Estates, IL

Principal Engineer — Develop Cathodic Protection System Design Manual for Military Base and Civil Works Structures, U.S.. Army Construction Engineering Research Laboratories, Champaign, Illinois

Expert Witness — Analysis of Mode of Failure Resulting in Gas Distribution System Leak leading to Explosion and Loss of Dwelling in Baltimore, Maryland, Name of Case and Client Confidential

Principal Consultant — Review of Corrosion Control Program on Steel, Cast Iron and Steel Reinforced Concrete Water Transmission Systems including Preparation of Recommendations for Changes to Improve Methodologies, City of San Diego, CA

Principal Consultant — Review Corrosion Protection Practices for Insulated Steel Underground Steam Heating Piping, Ft. Bragg Army Base, NC

Corrosion Consultant — Value Engineering Analysis (Multiple Projects) of Proposed Sludge & Reclaimed Water Pipelines & Potable Water Lines, City of San Diego, CA

Principal Corrosion Value Engineer – Member of Value Engineering Team responsible for Detailed Review and Prepare Alternative Recommendations for Corrosion Contrl on Hot Heating Pipe Heating System in Elevated Reinforced Concrete Roadway Ramps, Port Authority Bus Terminal, Port Authority of New York and New Jersey, NY

Principal Researcher — "Instant-Off" and Polarization Decay Measurement Methods on Cathodically Protected Steel Structures, Corrpro Companies, Inc., Medina, Ohio

Principal Researcher — Optimization of Precious Metal Oxide Titanium Based Anode Shapes and Configurations for Steel Reinforced Concrete Structures, Corrpro Companies, Inc., Medina, Ohio

Principal Consultant – Lock Miter Gate Cathodic Protection System Performance Evaluation Survey, Gridely Lock & Dam, City of Boston, MA

Principal Researcher — Development of Distributed Ribbon Type Precious Metal Oxide Coated Titanium Anode System for Cathodic Protection of On-Grade Fuel Storage Tanks, Corrpro Companies, Inc., Medina, Ohio

Expert Witness — Evaluate Corrosion Pattern and Morphology of Corrosion Attack on Interior of Copper Domestic Hot Water Piping System, Client Name Confidential, St. Louis, MO,

Principal Consultant — Evaluation of Corrosion Control Systems on 3 - 1,000,000 On-Grade Molten Sulfur Storage Tanks, Texas Gulf Sulfur, Moorehead City, NC

Expert Instructor– Prepare Presentation Materials and Present Multiple Courses on the Subject of Corrosion and Corrosion Control at the Research Offices of the Corps of Engineers – U.S. Army, Ft. Lee, VA

Expert Witness & Principal Consultant — Analysis of Stray Current Corrosion Leading to Failure of Oil Filled Pipe Type Power Transmission Cable in Conjunction with adjacent Water Distribution System and Light Rail Transit System, PECO Energy Company, Philadelphia, PA

Corrosion Consultant — Value Engineering Analysis of Condition of Existing Lead Based Painting System on Multiple Large Suspension Bridges providing Vehicle Access to the City of New York including Determining Most Effective Means for Removal and Replacement with State of the Art Coating System, New York City, NY

Expert Witness — Evaluate Corrosion Pattern and Morphology of Corrosion Attack on Exterior of Buried Propane Tank, Client Name Confidential, Orlando, FL

Principal Consultant – Preparation of Operations Manual for Steel Reinforced Concrete Building Moisture Removal System, EOP Systems, LaCrosse, WI

Develop New Anode Configuration for Seawater Immersed Aluminum Galvanic Anodes used to provide Cathodic Protection for Offshore Drilling and Production Platforms and At Shore Pier, Dock and Wharf Piles, Dow Chemical Company, Houston, TX

Principal Engineer – Conduct Continuing Evaluation of Cathodic Protection System Corrosion Control Effectiveness on Steel Solder Pile, 1st Hawaiian Center Building Authority, Honolulu, HI

Principal Engineer – Conduct Basic Research into the Corrosion Interaction Between Type 316L Stainless Steel and ASTM A-36 Grade Carbon Steel in Contact with Lightweight Fire Insulating Concrete, Steel Tank Insurance Company, Chicago, IL

Corrosion Consultant – Conduct Field Evaluation and Prepare Written Report with Remediation Recommendations for Structural Steel Building Components in Contact with Cement Mortared Brick in National Historic Building, US Department of Interior, North Carolina

Corrosion Consultant — Evaluation and Recommendations for Use Bonded Light Rail System, Greater Cleveland Regional Transit Authority, Bowser-Morner, Inc., Dayton, OH

Corrosion Consultant – Evaluation of Corrosion and Corrosion Control Procedures on New Ductile Iron Pipe Water Distribution System, Gross Builders, Inc., Sagamore Hills, OH

Co-Principal Engineer — Develop and Conduct Performance and Life Test Program on Alternative Aluminum Alloy Anodes for installation on Heated Oil Sub Sea Pipelines — Phillips Petroleum Company, Stavanger, Norway

Expert Witness and Principal Researcher — Analysis of Failure of Water Service Line in Vicinity of Impressed Current Cathodic Protected Medium and Low Pressure Gas Distribution System, Peoples Gas, Pittsburgh, PA

Principal Corrosion Engineer — Perform Computerized Corrosion Mitigation Survey and Analysis on approximately 600 miles of Partially Submerged and Partially Buried Sub-Sea Pipelines using various Positioning and ROV equipment, Total Oil Company, Aberdeen, Scotland

Principal Engineer — Research and Test Effectiveness of Existing Cathodic Protection System on Lock and Dam Gates, Construction Engineering Research Laboratories, U.S. Army Corps of Engineers, Champaign, Illinois

Expert Witness – Corrosion and Corrosion Control Expert Witness on Failure of Underground Storage Tanks in West Virginia, Name of Client and Location withheld, Active Legal Case.

Principal Engineer — Develop "State-of-the-Art" Design for Cathodic Protection on Lock and Dam Gates, Construction Engineering Research Laboratories, U.S. Army Corps of Engineers, Champaign, Illinois

Principal Corrosion Consultant – Failure of Ductile Iron Pipe at Wastewater Treatment Plant, Malcolm Pirnie, Inc., White Plains, NY

Principal Engineer — Development of "State-of-the-Art" Design, Plans and Specifications for Cathodic Protection of Water Storage Tanks, Construction Engineering Research Laboratories, U.S. Army Corps of Engineers, Champaign, Illinois

Keynote Speaker – Speech on “Corrosion Economics” for the Minnesota Department of Public Safety, Minneapolis, MN

Principal Consultant – Utilization of Corrosion Rate Measurement Methodologies for Evaluating Cathodic Protection System Effectiveness, LaGuardia Airport Runway Extensions over Long Island Sound, Port Authority of New York and New Jersey, NY

Principal Consultant — Study to Evaluate the Long Term Corrosion Durability of Galvanized Steel Culverts in the United States, National Corrugated Steel Pipe Association, Washington, DC

Principal Engineer — Corrosion Evaluation and Cathodic Protection Feasibility Study, 1,500,000 sq. ft. of wharf deck and substructure support members in the Arabian Gulf, Sultanate of Abu Dahbi, United Arab Emirates,

Expert Witness – Failure Analysis and Cathodic Protection System Operational Procedures Impacting System Effectiveness, Name of Project and Location Withheld at Client’s Request.

Expert Witness -- Buried Transmission Pipeline Coating System Failure Analysis including Effects of ICCP Cathodic Protection, Name of Project and Location Withheld at Client’s Request.

Underground Storage Tank (UST) Projects

Principal Instructor — UST Corrosion and Corrosion Control Training Courses, Region 7, Office of Underground Storage Tanks, U.S. Environmental Protection Agency, Kansas City, KN

Principal Consultant — Impact of Methanol and Ethanol Based Fuels on Corrosion of Steel U.S.T. Interiors, Steel Tank Institute, Lake Zurich, IL

Principal Consultant — Evaluation of Corrosion Conditions and Preparation of Plans & Specifications for Installing Cathodic Protection on Underground Heating Oil Storage Tanks, Gaston County School System, Gaston, NC

Principal Consultant — Obtain Structure Baseline Data and Prepare Detailed Design, Plans and Specifications for State-of-the-Art Environmentally Compatible Deep Anode Cathodic Protection for On-Grade Fuel Storage Tanks at Seymour Johnson AFB, Law Engineering, Inc., Raleigh, NC

Principal Corrosion Consultant — Develop 2-Day Training Courses and Manual on Corrosion Control and Testing of Regulated Underground Storage Tanks, U.S. Environmental Protection Agency, Washington, DC

Expert Witness — Corrosion Failure Analysis of 2 – 30K Gallon Emergency Fuel Storage Tanks, Concord, CA, Client and Project Specifics Confidential

Principal Corrosion Consultant — Evaluation of Inspection Methods for Determining the Extent and Depth of Corrosion Attack on UST's, 20 – 50K Underground Fuel Storage Tanks at Hunter Army Air Base, Georgia, Russell Corrosion Consultants, Baltimore, MD

Principal Instructor – Conduct more than 25, 2-Day Training Course on "Corrosion & Corrosion Control System Effectiveness Testing on UST's" for various Regional Environmental Protection Agencies and the UST State Regulatory Personnel for the States of Arizona, California, Delaware, Iowa, Kansas, Maryland, Missouri, New Jersey, New York, Nevada, Nebraska, Ohio, Pennsylvania, Virginia, West Virginia, and Utah

Principal Consultant – Perform Field Investigation and Design Corrosion Control System for 3 – 15,000 Gallon Pressurized Ethylene Oxide Underground Storage Tanks buried in Earthen Filled Reinforced Concrete Vaults, Henkel Corporation, Mauldin, NC

Expert Instructor – Corrosion and Cathodic Protection System Testing Procedures on Underground Storage Tanks, University of Wisconsin, Madison, Wisconsin

Expert Corrosion Consultant Witness — Corrosion Failure of Underground Storage Tanks in Indianapolis, IN area, Client and Project Location Confidential

Principal Consultant — Corrosion Probability Analysis using multi-variate linear and non-linear regression statistical techniques on underground storage tanks at 2095 Fuel Dispensing Sites, The Southland Corporation, Dallas, Texas

Principal Instructor — Corrosion and Corrosion Control Training Course for Steel Underground Storage Tank Cathodic Protection System Inspectors, Gilbarco, Inc., Greensboro, NC

Principal Consultant — Probability and Cause of Corrosion Protection Deterioration on STI-P3 Steel U.S.T.'s,. Steel Tank Institute, Lake Zurich, Illinois

Expert Witness — Evaluate Procedures Used by Major Oil Companies operating in the State of Texas in Mitigating Corrosion on Underground Storage Tanks at Fuel Service Station in Texas. Client Name and Location Confidential

Steel Reinforced Concrete Projects

Principal Consultant — Evaluation of Corrosion Conditions and Preparation of Detailed Plans & Specifications for Installation of Cathodic Protection on Submerged Steel Reinforced Concrete Elevating Pool Floor, Mecklenburg Aquatic Center, Charlotte, NC

Expert Corrosion Engineering Witness — Failure of Cathodic Protection Anode Systems on 400,000 Square Foot Parking Garage, St. Louis, MO, Client and Specific Project Location Confidential.

Principal Corrosion Consultant — Evaluation of Corrosion and Develop Remediation Plan for Corrosion on Metals in Chloride Contaminated Soil Cements, Construction Technology Laboratories, Inc., Skokie, IL

Principal Consultant — Investigation Corrosion and Develop Corrosion Mitigation Program for Steel Soldier Beam “H” Piles in Chloride Contaminated Soil Cement supporting 55 Story Office Building, 1st Hawaiian Bank, Honolulu, HI

Principcal Corrosion Consultant — Federal Highway Administration Technical Work Group - Implementation of Strategic Highway Research Program (SHRP) developments for Concrete and Structures, Washington, DC

Principal Corrosion Consultant — Evaluate Corrosion and Corrosion Control Methods Available for Pre-Stressed Steel Cylinder Cement Mortar Coated and Lined Pipe, Corrpro Companies, Inc., Medina, OH

Principal Engineer and Research Group Chairman — Development of Federal Highway Administration Manual “Cathodic Protection of Reinforced Concrete Bridge Elements”, Contract C102D, Strategic Highway Research Program (SHRP), Washington, DC.

Principal Consultant — Stray DC Current Corrosion Investigations on Various Steel Reinforced Concrete Structures including the World Trade Center Building, numerous bridge structures and several subway tunnel systems, The Port Authority of New York and New Jersey

Principal Consultant — Development of Stray Current Investigation and Mitigation Plan, Anchorage International Airport Steel Reinforced Concrete Elevated Highway and Entrance Ramps, City of Anchorage, Alaska

Principal Consultant — Investigation on the Extent and Pattern of Corrosion and Means for Long Term Monitoring and Programmed Prevention, Loveland Pass Steel Reinforced Concrete & Tile Tunnel Lining Panels, U.S. Interstate 80, State of Colorado Department of Transportation, Loveland, Colorado

Principal Consultant — Evaluation of Corrosion Protection Systems for Bridge Stay Cables and Anchorage’s, Federal Highway Administration, Washington, DC

Principal Consultant — Perform Corrosion Evaluation and Develop Detailed Plans & Specifications and Provide On-Site Construction Implementation Inspection for the Installation of Galvanic Anode Cathodic Protection System for Pre-stressed, Post-tensioned 400,000 Square Foot Steel Reinforced Concrete Deck, City of Wilkes-Barre, PA

Expert Witness – Expert Corrosion Consultant and Witness in the Investigation and Analysis of the Deterioration of Corrosion Control Sytem Effectiveness, Multi-Story Parking Garage System, Madison, Dane County Parking Authority, Wisconsin

Principal Consultant — Electrochemical Chloride Removal and Protection of Concrete Bridge Components, Strategic Highway Research Program, Washington, DC

Project Administrator and Co-Principal Investigator, F.H.W.A. Research project DTFH61-85-C-00124 to prepare textbook on "Corrosion and Corrosion Control of Steel Reinforced Concrete Bridge Decks" and develop a Training Course based on this textbook material including an Instructor's Guide, Student's

Workbook, and present 24, 1 week courses at various locations throughout the United States for the U.S.. Department of Transportation

Principal Consultant — Close Interval Corrosion Potential Study on 24 Foot Diameter Steel Reinforced Concrete Siphon Pipe, U.S.. Bureau of Reclamation, Phoenix, Arizona

Project Consultant — F.H.W.A. Research Project DTFH61-84-C-00119, "Further Improvements in Cathodic Protection for Steel Reinforced Concrete Structures" including designing, testing, inspecting and adjusting of eight different cathodic protection systems on two bridge decks in Ohio and Virginia

Principal Consultant — General Corrosion Engineering Consulting Services including corrosion testing, evaluation and design, construction supervision, inspection, testing and commissioning corrosion control systems for various steel reinforced concrete bridges, tunnels, parking garages, etc., The Port Authority of New York and New Jersey

BUSHMAN & Associates, Inc.
CORROSION CONSULTANTS
P.O. Box 425, Medina, OH 44258 • Phone 330/769-3694, Fax 330/769-2197

Curriculum Vitae of
Dr. Bopinder S. Phull
Associate Corrosion Consultant – Bushman & Associates, Inc.

Educational Background:

B.Sc., Materials Science, University of Bath (UK)
Ph.D., Corrosion Science & Engineering, University of Manchester (UK)

Certification:

NACE Certified Corrosion Specialist #4824, 1993
NACE Certified Cathodic Protection Specialist #4824, 1993

Years of Experience: 31

Citizenship: United States

Employment & Project Experience:

CAPCIS

In 1978, Dr. Phull joined the Corrosion & Protection Center Industrial Services (CAPCIS) as a Project Officer. CAPCIS was a corrosion consulting/testing company based in Manchester (U.K.). He worked there until March 1984 on a wide variety of projects, ranging from corrosion failure analysis to multi-client, research-oriented, multi-year investigations. Examples of project diversity include:

- Stress corrosion cracking of stainless steel by boiler carryover
- Selection of stainless steels for marine and brewery applications
- Coatings selection, testing and design of cathodic protection for underwater-cable transponder housings
- Soil corrosion of steel, cast iron and ductile iron pipes
- State-of-the-art surveys on cathodic protection of underground and offshore platforms and subsea pipelines
- Evaluation of corrosion inhibitors for automotive cooling systems
- Evaluation of corrosion inhibitors for submarine crude oil pipelines
- Water/biocide treatment of hydrotest water for offshore pipelines
- Testing of sacrificial anodes for hot, sour brine service
- Pitting and crevice corrosion of stainless steels in chloride environments

Much of the activities performed on projects and experience gained were “hands on”, including site visits, metallography, scanning-electron microscopy, wet-chemical, energy-dispersive x-ray and diffraction analysis. In addition Dr. Phull assisted in the development of electrochemical methods for corrosion testing, on-line monitoring, and plant surveillance. He also attained working knowledge of many non-destructive inspection techniques such as DPI, MPI, UT, Borescope visual examination, eddy-current, radiography, etc. Activities typically also included proposal and report preparation, project management, and making results' presentations to clients.

<u>LaQue Center for Corrosion Technology, Inc.</u>

In April 1984, Dr. Phull joined the LaQue Center for Corrosion Technology, Inc. in Wrightsville Beach, North Carolina, USA, as a Corrosion Engineer. During his tenure there he was promoted to the position of Senior Corrosion Engineer and later Principal Corrosion Engineer. Following is a summary of exemplar project activities and experience:

- Corrosion of stainless steels, nickel alloys, titanium, and coatings in flue-gas desulfurization systems
- Evaluation of anti-corrosion coatings under static and dynamic flow conditions
- Testing of coatings for antifouling resistance
- Testing of coatings for cathodic disbondment-resistance
- Characterizing/Evaluating corrosivities of marine environments
- Performance of materials in marine environments, e.g. carbon steels, weathering steels, stainless steels, aluminum alloys, copper alloys, nickel alloys, titanium, coatings
- Corrosion-damage assessment and cathodic protection design for historic museum battleship
- Packaging requirements for ship cargoes to obviate corrosion
- On-line corrosion monitoring in power plants
- Development of corrosion training programs for technical and non-technical personnel
- Failure analyses of shell-and-tube and plate-and-frame heat-exchangers; pumps, valves, piping systems
- Corrosion evaluation in dry and wet fire-fighting systems
- Performance of rebar materials in concrete
- Materials selection for nuclear-waste treatment plants and nuclear repositories
- Stress corrosion, hydrogen-embrittlement, and corrosion fatigue testing
- Evaluation of heavy-metal release in potable water and synthetic body fluids
- Corrosion-resistance evaluation of medical prosthetic materials and devices
- Galvanic corrosion compatibility testing and materials selection
- Evaluation of corrosion resistance of automotive radiator materials and coatings
- Evaluation of materials and microbiologically-influenced corrosion in cooling water systems
- Cathodic protection system design for offshore-platform clamps
- Expert testimony on galvanic corrosion in ship piping system
- Evaluation of sacrificial anode consumption in ozonated-seawater ship ballast tanks
- Testing of sprinkler-head materials/components for firewater systems
- Localized corrosion evaluation for copper-base alloys, stainless steels, and nickel-base alloys
- Evaluation of low-level chlorine detection devices
- Corrosion control for traveling screens and strainers in seawater-cooled power plant

Activities at the LaQue Center typically also included proposal and report preparation, project management, as well as technical hands-on involvement, and formal presentations of reports to clients.

<u>Bushman & Associates</u>

Shortly after the LaQue Center was closed, Dr. Phull agreed to become Associate Corrosion Consultant with Bushman & Associates. He now has 31 years of experience in corrosion testing, research, failure analysis, and education. His specialty areas include marine environments, FGD systems, corrosion evaluation and monitoring of buried and submerged pipelines, use of computer controlled corrosion rate monitoring and use of remote monitor systems to measure in-situ corrosion rates and evaluate the performance effectiveness of corrosion control systems. He is a NACE Certified Corrosion and Cathodic Protection Specialist, and a course instructor. During his tenure at Bushman and Associates, some of his more notable projects have included:

- Testing, Implementation Supervision and Evaluation of Corrosion Rate and Corrosion Control Remote Monitoring Systems at Multiple Military Facilities
- Establishment and Monitoring of Atmospheric Corrosion Rates on Various Metal Alloys Exposed Both Near and Remote from Ocean Spray in Okinawa, Japan
- Testing and Monitoring of Corrosion Mitigation Effectiveness of Several Different Corrosion Inhibitors as Applied to Steel Reinforced Concrete Structures
- Implementation of Computer Controlled Linear Polarization Resistance Testing as a Means for Determining Corrosion Rate Mitigation on Steel Reinforced Concrete Structures
- Development and Implementation of Computerized Synchronous Monitoring of HVDC Transmission Stray Currents on Marine Wharf Steel Piling
- In his professional career, Dr. Phull has also developed and taught many generic and customized corrosion courses to clients from a wide range of industries. He is currently an approved instructor for the NACE Basic Corrosion Course and Designing for Corrosion Control Course.

Current/Past Society Memberships and Professional Activities:

- American Society for Testing and Materials (ASTM) - past
- ASM International (formerly known as the American Society for Metals) - past
- Institute of Corrosion (U.K.) - past
- NACE International (formerly known as the National Association of Corrosion Engineers) - current
  - Past Chairman of NACE Symposium T-7C on Marine Corrosion (1999)
  - Past Chairman of NACE Symposium T-5F on Corrosion in Air Pollution Control Systems (1986)
  - Past Chairman of NACE Unit Committee T-5F on Corrosion in Air Pollution Control Systems (1988)
  - Past member of NACE Publications Committee
  - An official reviewer of papers for NACE International technical symposia and journal publications
  - Secretary, NACE Unit Committee T-7C on Marine Corrosion (1999 - 2001)
  - Chair of NACE Committee STG – 44 (2002-2004).
  - Program Coordinator, Technology Management Group N2 (2005-2007)
  - Member Annual Conference Program Committee (ACPC 2007-2009)

List of Recent Publications/Presentations

1. "Monitoring the Corrosivities of Atmospheric Exposure Sites," by B.S. Phull and W.W. Kirk, *Proceedings of Coating Evaluation and Durability Conference*, Steel Structures Painting Council, Pittsburgh, PA, April 1991.

2. "Cathodic Protection and Its Effects on Coatings," by B.S. Phull, 1991 Marine & Proceedings of Offshore Maintenance Coatings Conference, National Paint & Coatings Association, Wrightsville Beach, NC, June 1991.

3. "Fundamentals of Corrosion and Its Control," Course Notebook by B.S. Phull, for training programs conducted by LaQue Center for Corrosion Technology, Inc., c 1991.

4. "Engineering Alloy Behavior in Marine Environments," by B.S. Phull, D.G. Melton and R.M. Kain, Presented at the Marine Corrosion Session of the NACE Northeast Regional Meeting, Atlantic City, NJ, October 13-16, 1992.

5. "Corrosion Behavior of Highly-Alloyed Nickel Stainless Steels in a Model Sulfur Dioxide Scrubber System" by R.W. Ross and B.S. Phull, Presented at AIRPOL/92 Conference, sponsored by Nickel Development Institute.

6. "Technical Note: Stress Corrosion Cracking Behavior of Two High-Strength Al-xCu-Li-Ag-Mg-Zr Alloys" by W.C. Moshier, B.A. Shaw, W.T. Tack, and B.S. Phull, *CORROSION*, Vol. 48, No. 4, NACE, 1992.

7. "Corrosion Behavior of Engineering Alloys in Marine Environments", by R.M. Kain and B.S. Phull, Presented at ASME Energy Sources Technology Conference, American Society of Mechanical Engineers (Ocean Engineering Division), New Orleans, LA, January 23-26, 1994.

8. "Seawater Corrosivity Around the World - Results from Five Years of Testing", by B.S. Phull, S.J. Pikul, and R.M. Kain, Presented at ASTM Symposium "Corrosion in Natural Waters, Norfolk, VA, November 7, 1995.

9. "Recognizing Corrosion Failures", by B.S. Phull, Presented at Charlotte Plant Engineering & Maintenance Conference, Charlotte, NC, November 8, 1995.

10. “Forms of Corrosion Affecting Various Alloys in Natural Waters”, by B.S. Phull, ASTM STP-1300 - Corrosion in Natural Waters, American Society for Testing and Materials, West Conshohocken, PA, 1996.

11. "Case Histories Dealing with Crevice Corrosion Experiments in Seawater," by R.M. Kain and B.S. Phull, Presented at NACE CORROSION/95, Research Symposium, NACE International, Denver, CO., March 24-29, 1996.

12. “Corrosion Performance of Ni-Coated Rebar in Concrete”, by B.S. Phull and R. M. Kain, Proceedings of Conference on Understanding Corrosion Mechanism in Concrete - A Key to Improving Infrastructure Durability, MIT, Cambridge, MA, July 27-31, 1997.

13. “Corrosion Resistance of Ni-Containing Engineering Materials in Marine Environments”, by B. S. Phull and R. M. Kain, Presented at Symposium on Nickel and Cobalt Alloys, The Canadian Institute of Mining and Materials Conference, Sudbury, Ontario, Canada, August 17-20, 1997.

14. “How to Tell if Corrosion is Really the Cause of Failure”, by B.S. Phull, Presented at Materials Solutions Conference - 1997, ASM International, Indianapolis, IN, September 15-18, 1997.

15. “Long-Term Durability Testing and Performance in Marine/Coastal Environments”. Plenary Lecture, by B.S. Phull, Presented at 2nd Corrosion Middle East Conference & Exhibition, Dubai, United Arab Emirates, November 29-December 1, 1998.

16. “Corrosion Resistance: Alloy Alternatives for Severe Marine Environments”, by B.S. Phull and R. M. Kain, Underwater, Fall 1998, pp. 105-109.

17. “Corrosion Testing/Monitoring to Solve Plant Corrosion Problems”, by B.S. Phull, EPRI Corrosion and Degradation Conference, St. Petersburg, FL June 2-4, 1999.

18. “Corrosion Behavior of Conventional and Advanced Alloys in Marine Environments”, B.S. Phull, R.M. Kain, Presented at Ultra Steel 2000, Tokyo, Japan, January 11-14, 2000

19. “Field Testing to Determine Corrosion Resistance of Duplex and 4-6% Mo-containing Stainless Steels in FGD Scrubber Absorber Slurry Environments”, B.S. Phull, W.L. Mathay, R.W. Ross, Paper No. 578, CORROSION/2000, NACE International, Houston,TX, March 26-31, 2000.

20. “Thirty-Eight Years of Atmospheric Corrosivity Monitoring”, B.S. Phull, R.M. Kain, S.J. Pikul; presented at ASTM Symposium, Miami, FL, November 13-14, 2000.

21. “1940 Till Now -- Long Term Marine Atmospheric Corrosion Resistance of Stainless Steel and Other Nickel Containing Alloys”, R.M. Kain, B.S. Phull and S.J.Pikul, ASTM Symposium on Indoor and Outdoor Atmospheric Corrosion, May 2001.

22. “Wireless Remote Monitoring of Cathodic Protection Systems”, L. D. Stephenson, A. Kumar, J. B. Bushman and B. Phull, Materials Performance, Vol. 48 (No.6), June 2009, pp36-41, NACE International, Houston, TX.