

1.0 INTRODUCTION

In August 1995, the National Energy Board (NEB, the Board) initiated a public inquiry into the issue of the near-neutral pH form of stress corrosion cracking (SCC) found on Canadian pipelines. The Inquiry Panel's report to the Board¹ contained 27 recommendations to promote public safety of Canada's oil and gas pipelines, one of which was a requirement that each pipeline company develop and implement an SCC management program. The following items were considered to be requirements in a SCC management program:

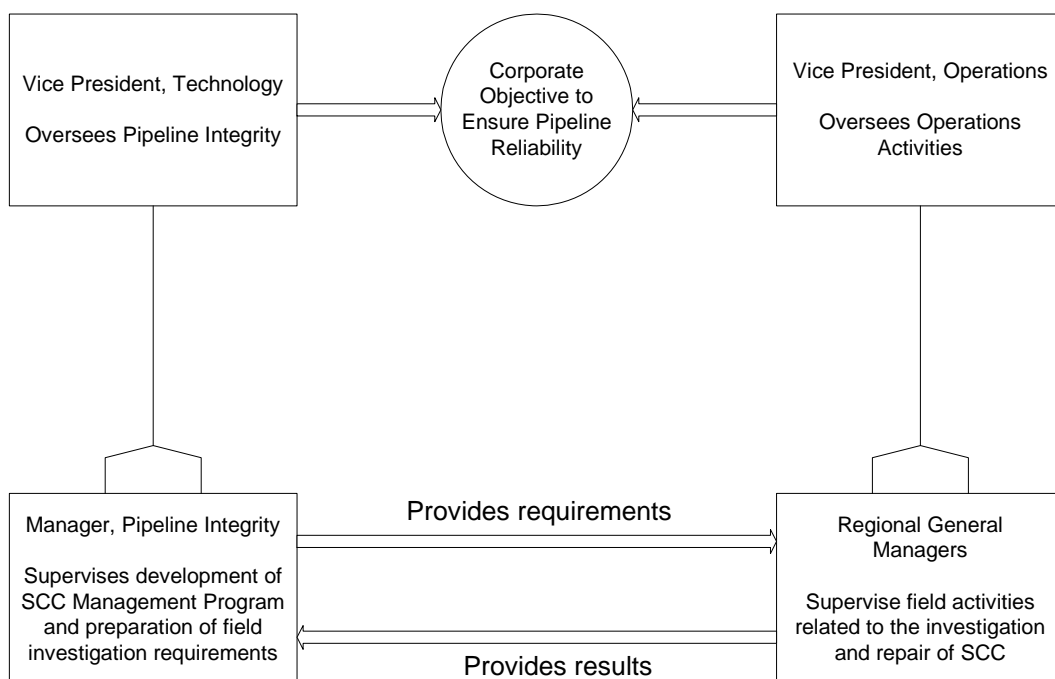
- Identification of accountability for the implementation of the program
- Review of the company's entire pipeline system and regular updating
- Consideration of the consequences and the probabilities of a failure when planning activities to investigate, mitigate, and prevent SCC
- The three principal components to be found in the SCC management program are: determination of pipeline susceptibility to SCC and active monitoring of pipelines believed to be susceptible to SCC; identification of the criteria to consider when deciding upon options to mitigate "significant" SCC; and recording and sharing information on susceptible pipelines.

Enbridge Pipelines Inc. (Enbridge), more specifically the Pipeline Integrity Department, reviews this program annually to ensure that the learnings from the previous years work are implemented. The program was initially directed towards the Canadian pipeline system however it is now applicable to the entire mainline system. The plans described within this document are developed through the overall department planning process and they provide input to other department planning such as in-line inspection and excavation program schedules. This program also makes up an important part of the company's overall crack management program.

¹ Public Inquiry Concerning Stress Corrosion Cracking on Canadian Oil and Gas Pipelines, MH-2-95, Report of the Inquiry, National Energy Board, Calgary, Alberta, November 1996.

1.1 Organizational Responsibility

To ensure that company objectives towards safe and reliable pipeline operations are upheld, the implementation of the SCC management program is under the joint accountability of the Vice President, Technology and the Vice President, Operations. The Manager, Pipeline Integrity is responsible for developing the specific program requirements and field investigation guidelines. The Regional General Managers ensure that field activities related to the investigation and repair of piping affected by SCC are completed and that the information is provided to Pipeline Integrity for analysis. The following chart summarizes the interrelationship between the key areas of responsibility for SCC activities and the associated Responsible Parties.

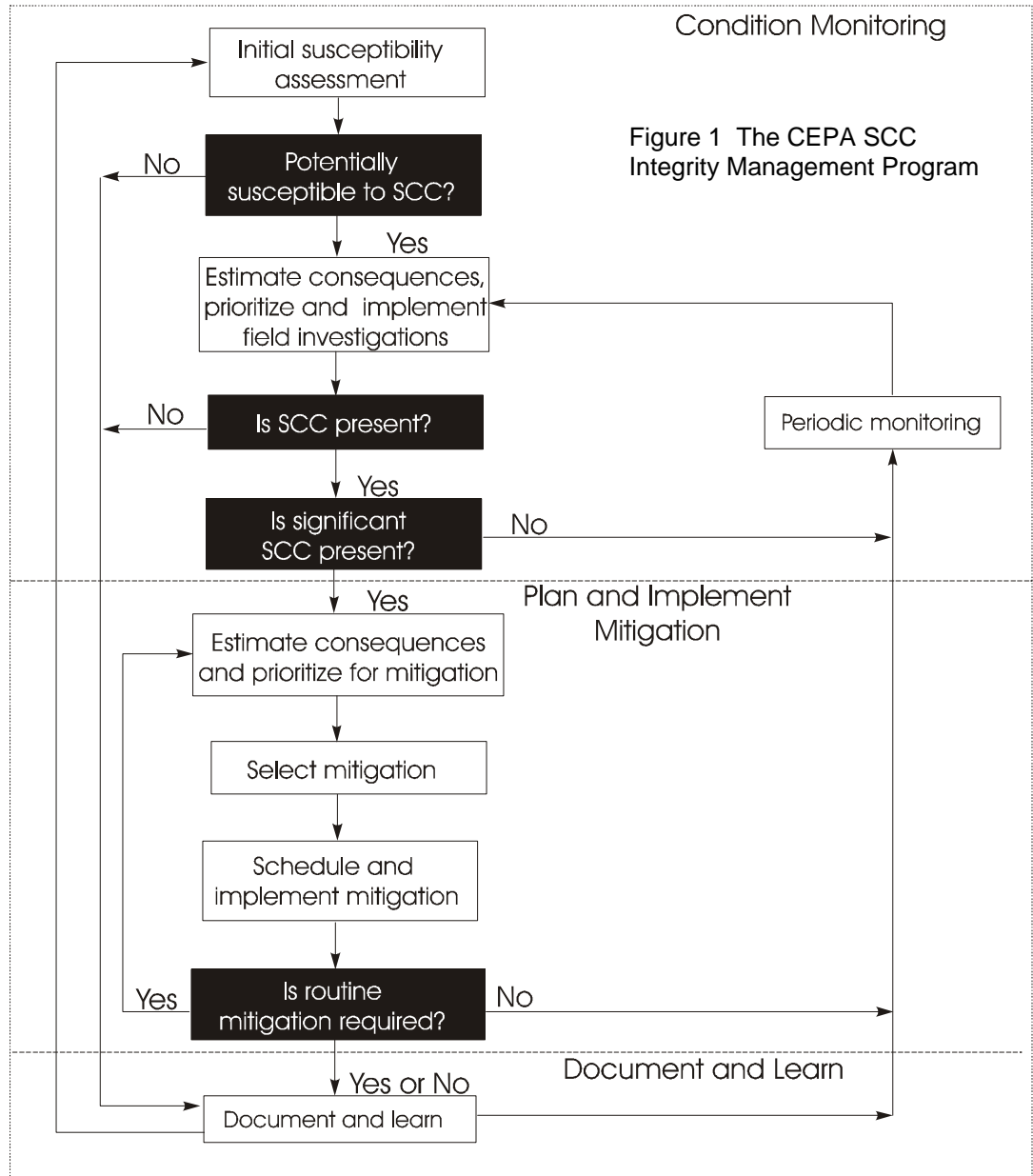


1.2 Program Review and Updates

This document describes a program that is based on the current understanding of SCC on buried pipelines. It will be reviewed and updated on a regular basis to incorporate new technology and understanding of this phenomenon. Revisions will be prepared by the Manager, Pipeline Integrity, and material issues will be reported to the Vice President, Technology and the Vice President, Operations.

2.0 SCC MANAGEMENT PROGRAM OVERVIEW

As a member of the Canadian Energy Pipeline Association (CEPA), Enbridge had participated in the development of a basic framework for a SCC management program (See Figure 1)², and has subsequently adopted this framework as the basis for the Enbridge program conducted system wide. The three general areas covered by the program include condition monitoring, planning and implementing of mitigation programs, and documenting and sharing of information with the pipeline community. Specific details of our approach to the SCC management program are discussed in the following sections.



² Stress Corrosion Cracking Recommended Practices, Canadian Energy Pipeline Association, Calgary, 1997.

2.1 Initial Susceptibility Assessment

The initial susceptibility assessment requires that an inventory be completed of all of the pipelines within the Enbridge system, identifying all of the coating types and where they are located. The Pipeline Integrity Department maintains a listing of the pipelines that includes the mileposts, the years of construction, the description of the pipe material, and the coating types for all of the lines in the Enbridge system.

2.2 Determine Potential Susceptibility to SCC

The type of external coating broadly determines the potential susceptibility.

	Coating Type	Kilometers of Pipe	
		Canada	United States
Susceptible	Polyethylene (PE) tape	2847	1651
	PE Tape on Girth Welds*	883	0
	Mummy wrap (wax coating)	32	0
	Double Wrap PE Tape	601	0
Not-Susceptible	Coal tar enamel	2641	2910
	Extruded polyethylene	1015	26
	Fusion bond epoxy/Polyurethane	1400	1600
	High Performance Composite Coating	541	0
Total		9077	5490

*Only noted for mainline coated with not-susceptible coating.

As is shown in the table approximately 39% of the pipeline system is considered to have susceptibility to SCC. Approximately 90% of this susceptible pipe is ranked as having a high susceptibility while the remainder is Double Wrap PE Tape coated which has a very low susceptibility.

2.3 Prioritize and Implement Field Investigations

All sites that are excavated during the course of Enbridge’s maintenance programs are examined for SCC using non-destructive examination methods, including magnetic particle inspection. The company’s primary focus is directed to selecting excavations based on ILI results. The ILI tools that are used include crack detection tools that are proven to identify SCC. Discovery of SCC on a pipeline influences the selection of ILI tools scheduled for that particular pipeline.

All excavations, regardless of intent, are conducted in accordance with Company procedures that specify the requirements for nondestructive testing (NDT), data collection, and repair. As per the Field Assessment Procedures provided in Appendix 1 of this document, all exposed welds and areas with external metal loss are inspected for SCC. Requirements for pressure restrictions during the course of investigative activities are provided in the Enbridge Operations and Maintenance Procedures Manual.

2.4 Significant SCC

Enbridge utilizes the definition of “significant” SCC that has been adopted in the CEPA Stress Corrosion Cracking Recommended Practices. The Pipeline Integrity Department will administer the reporting requirements for the discovery of “significant” SCC.

The assessment of “significant” includes the definition of critical crack lengths. The critical crack lengths are calculated using a fracture mechanics analysis that requires toughness measurements of the in-service pipe. Toughness data compilation is an ongoing process that depends upon the availability of samples from existing piping. Toughness measurements and pipe body critical crack size calculations have been completed for representative materials from the Enbridge pipelines. This allows us to provide accurate estimates of significant crack sizes to be used by field crews during excavations.

2.5 Periodic Monitoring

If SCC is found but the severity is deemed not to be “significant”, periodic monitoring will be conducted. Where the information is available, crack growth rates will be used to assist in developing the requirements for the frequency of periodic monitoring.

If SCC is found and the severity is deemed to be “significant”, a thorough analysis of the characteristics pertaining to the site where the SCC was found will be performed. Similar locations along the pipeline or pipeline segment can then be identified for potential additional excavations or periodic monitoring.

Company policy dictates that investigations for SCC will be conducted whenever possible when the pipe is exposed during maintenance activities as dictated by the size of the excavation and the presence of significant coating damage or external corrosion.

2.6 Plan and Implement Mitigation

It has been our experience that SCC is not extensive on the Enbridge pipeline system and when discovered, procedures to mitigate SCC are implemented immediately. These include grinding to remove the cracks or sleeving if the cracks exceed fitness for purpose criteria after grinding is complete. All piping that has been excavated is recoated with a high integrity coating for pipe surface protection.

The procedures that are used to mitigate SCC and long term measures that could be implemented are reviewed annually by the Pipeline Integrity Department to ensure that recent field observations are considered when updating SCC management activities.

2.7 Document and Learn

All pertinent data will be entered into the Enbridge Pipeline Integrity Tracking System (PITS) database which serves as a central library of integrity investigations. This database has the ability to be searched and filtered to perform analysis and trending.

Trending of the data will provide valuable information describing the success of the SCC program activities, specifically as it relates to locating sections of piping which exhibit SCC. The results of these investigations are used to continuously improve the predictive capabilities of the SCC program on the basis of Enbridge specific information.

2.8 Trending

The data that is collected from both ILI and field investigations can be trended in many ways. The goal of the trending work is to determine the most valuable indicators of the potential for SCC occurrence on the pipeline system. Current trending identified an increased SCC occurrence associated with the following indicators.

- Coating: polyethylene tape.
- Nominal Stress: locations with higher nominal stress (i.e. near discharge, low relative elevation, etc.).
- Pressure Cycles: location subjected to larger quantities of aggressive pressure loading rates.

Work to identify additional characteristics that are useful for planning purposes is continually being completed. The results of these trends are utilized in the in-line inspection program planning process.