Inspection and Maintenance of Crude Oil Transmission Pipelines in the Great Lakes-St. Lawrence River Region

Introduction

The Great Lakes-St. Lawrence River (GLSLR) region is a major hub for the transportation of crude oil. Pipelines are the traditional preferred mode of transportation for oil; more oil is transported through the region by this mode than by any other. Understanding the potential hazards associated with pipelines and the measures taken to minimize risk is important for stakeholders in the region.

Typical Pipeline Vulnerabilities

Pipeline operators monitor conditions to mitigate the risk of failure. Some typical sources of pipeline failures include corrosion, environmentally-assisted cracking, equipment failure, material defects, environmental incidents, and human interference.

Corrosion is a natural phenomenon that occurs whenever metal is exposed to the surrounding environment. This electrochemical process strips ions from the surface of the steel pipe. Although pure oil does not present a corrosion risk to the pipeline, sediment and water carried by crude can cause internal corrosion.

Steel is generally a strong and malleable metal; however, improper installation and/or maintenance of steel pipelines can lead to "stress induced separation of the metal", or **cracking**. Oil pipeline cracks have three general causes- cyclic fatigue, stress corrosion, and manufacturing error.

Deformations in steel pipelines are generally caused by environmental incidents and human interference. They can be classified in two categories: gouges and dents. Gouges and dents commonly affect the coating of a pipeline as well as the steel itself, leading to increased corrosion.

Who Conducts Inspections?

	United States	Canada
Federal	The Pipeline & Hazardous Materials Safety Administration (PHMSA) inspections are scheduled on a case by case basis. PHMSA tends to prioritize pipelines that have a history of leakage, are near urban centers, and/or present excessive risk to the environment.	The National Energy Board (NEB) is not required to inspect pipelines at any specific interval. Instead, they use a risk-informed model to prioritize the inspection of pipelines on a case by case basis. All inter-province and international oil pipelines are under federal jurisdiction.
State/ Provincial	States can be granted the power to regulate and inspect intrastate pipelines. To become certified, states must adopt the minimum pipeline safety regulations. Minnesota, Indiana, and New York are the only hazardous liquid certified states in the GLSLR region.	Provinces are responsible for the regulation of intra-province pipelines, but these pipelines are largely for natural gas distribution, and not transmission.
Operator	Operators are required to carry out written plans for inspection and maintenance that have been submitted to and approved by the PHMSA. They must also establish inspection intervals not to exceed five years.	Operators are responsible for inspecting their pipelines, and they are required to submit maintenance plans to the NEB for approval at least every three years. They must also submit an annual status report to the NEB

Mechanical Tools

Once a pipeline has been installed, the best way for an operator or regulator to inspect it is to use a smart pig. These specialized tools record data that operators can use to ascertain the health of a pipeline.

Failure Concern	Tool Type	Method	Example
Deformation	Caliper Inspection Tool	Uses highly sensitive spring loaded arms to detect variance in the internal diameter of a pipeline.	
Cracking	Circumferential Crack Inspection Tool	Uses high resolution ultrasonic waves to identify separation in the steel pipeline	
Corrosion	Magnetic Flux Leakage Tool/ Transverse Flux Inspection Tool	Induces a magnetic field within the pipeline, and measures changes to detect corrosion pits	

Monitoring Techniques

Inspections can uncover abnormalities that could lead to future failures, but because they are snapshots in time, it is important that operators maintain control centers for the purpose of monitoring pipelines. 24/7 monitoring allows pipeline operators to detect failures as soon as possible. Routine inspections of facilities by Field Operations and Maintenance personnel also help detect failures between inspections.

Controllers oversee control rooms. Fatigue management and certification are mandated by the federal government.

SCADA systems continuously relay information about product flow. Controllers monitor the data 24/7.

Operators maintain the right of way to make inspections and repairs quicker and easier.

Aerial and ground inspections are conducted at least every 3 weeks, 26 times a year.

Abnormalities call for preventative digs, hydrostatic pressure testing, and in-line inspections.

Abnormalities exceeding federal standards require repair. Operators may elect more stringent standards.

Preventative Measures

Through proper maintenance and inspection, operators can manage the integrity of their pipelines and mitigate the risk of failure. A variety of preventative measures target specific common failure conditions.

Deformation

- Toll-free hotlines allow property owners to locate pipelines before excavation; owners are required by law to use these resource
- Operators are required to mark pipeline right-of-ways

Corrosion

- External coatings keep the steel pipeline out of contact with the environment, coatings materials are tailored to the pipeline (e.g., epoxy, tape, enamel, cement)
- Cleaning ensures that the pipeline is operating at peak efficiency and that internal corrosive build up is removed
- Cathodic protection uses an impressed current to protect the pipeline from external corrosion. Operators are required to maintain certain electrical standards set by the National Association of Corrosion Engineers to ensure protection.

Cracking

- Pipelines that are under water require bracing
- Control rooms monitor and inhibit pressure fluctuations to reduce cyclic fatigue

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