LONG DISTANCE INLINE INSPECTION OF AN UNPIGGABLE NATURAL GAS PIPELINE WITH ROBOTIC TECHNOLOGY

By: David Gian, Intero Integrity Services BV, Netherlands
and Rod Lee, Intero Integrity Services BV, Netherlands

Abstract

In-line inspection (ILI) is a pipeline assessment method used by operators to receive a comprehensive integrity assessment of their pipeline. However, ILI may become unfeasible due to factors such as insufficient flow/pressure parameters for propulsion, pipeline features such as valves, back-to-back elbows and unbarred tees, as well as the lack of infrastructure such as launcher and receiver for tool entry and exit. These pipelines are deemed as difficult to inspect, or "unpiggable," and are often limited to other integrity assessment methods such as Direct Assessment or hydrostatic testing.

The Pipe Explorer MFL robot fleet from Intero Integrity Services, is powered by rechargeable batteries and can travel up to 600 meters under live gas conditions before returning to the size-on-size hot-tap fitting or 800 meters from point-to-point with the use of an exit hot-tap fitting. The inspection distance may also be extended by cascading in-line-charging (ILC) stations until the desired inspection length is obtained. With Intero's in-line-charging system, Pipe Explorer robots are charged in-line and subsequently may continue the inspection up to another 800 meters (point-to-point) to the next ILC station or receiver hot tap fitting.

This paper reviews the process, execution, and data from the use of a Pipe Explorer MFL robot for long distance inspections that are several kilometres in length by examining a real-world 8.3 km, nine-day inspection. This inspection utilized four hot tap fittings for the Pipe Explorer to enter and exit the pipeline, as well as nine separate charging points. The resulting comprehensive MFL, deformation, and video data provided the operator with the integrity information required for continual undisrupted operation.

Introduction

Across the globe, there are pipelines that prove difficult to inspect using traditional methods due to a variety of reasons. Whether the infrastructure has challenging features, impassable components, or little to no flow, launching and receiving inline inspection pigs may have previously been impractical or impossible.

Over the summer of 2019, a natural gas and electricity supplier in Winnipeg, Manitoba partnered with Intero Integrity Services to plan and execute the robotic inspection of the Brandon lateral: an 8.3 km 10-inch pipeline which was otherwise considered "unpiggable".

Since 2010, Intero Integrity Services, has been mitigating the challenges of traditional pigging by utilizing their fleet of tetherless, robotic crawlers known as Pipe Explorers. Ranging from 6 to 36 inch in diameter, Intero's Pipe Explorer robots are able to perform Magnetic Flux Leakage (MFL) sensing, Laser Deformation Sensing (LDS), and video inspection on pipelines that are either in- or out-of-service. Additionally, Pipe Explorer robots are able to be recharged inside the pipe by using a proprietary in-line charging (ILC) technology which extends the range of the robots and allows for the inspection of longer distances. The ILC system operates as illustrated in Figure 1.

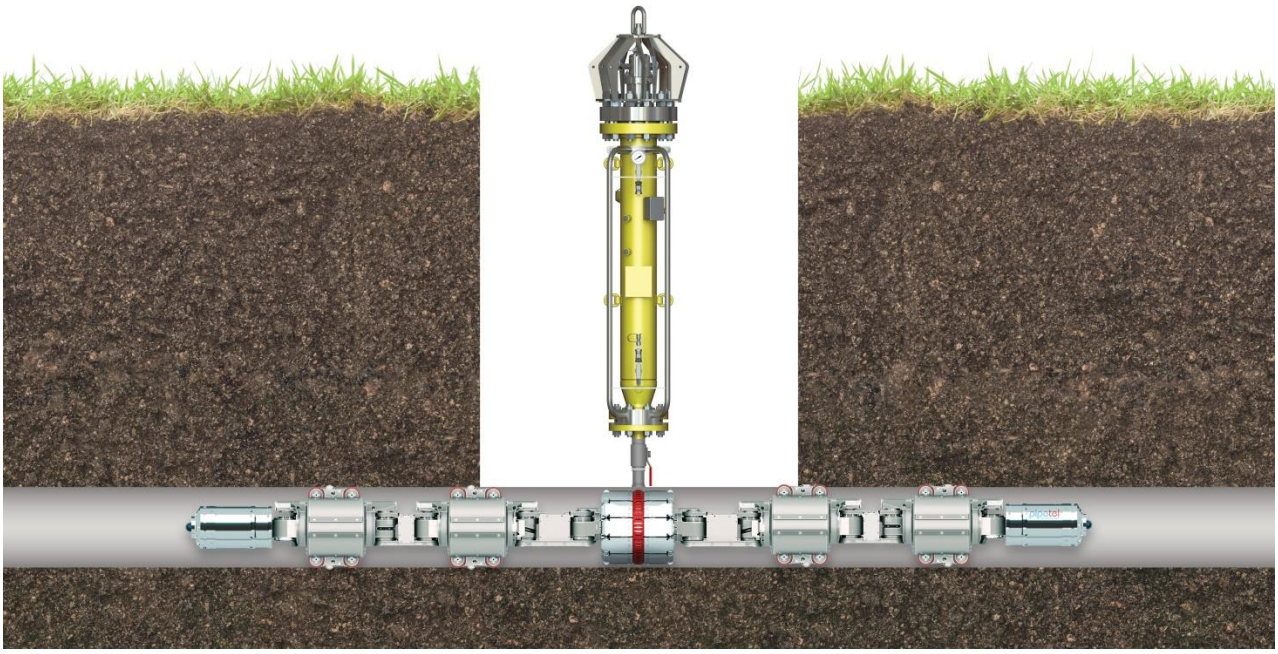

Figure 1: A Pipe Explorer robot with In-line Charging Vessel

The Pipeline Inspection Challenge for A Natural Gas Operator

The Brandon lateral is a previously uninspected 8.3km length of pipe that stretches between the city of Brandon and the hamlet of Forrest. The limits of the segment to be inspected were defined by a plug valve and a valve station which were both unsuitable for launching and receiving traditional pigging equipment. Additionally, as the pipeline had been built in the 1950s, the pipeline geometry, fittings, wall thickness, and cleanliness were all unknown factors and no records existed to confirm this information prior to the inspection. Furthermore, there was a possibility of different pipeline diameters within the segment and there was no feasible location to add a permanent pig launcher.

Due to the unknown geometry of the pipeline, the number of fittings and excavations required, the trajectory of the pipeline through farmland, and potential weather delays, the decision was taken to inspect the pipeline while it was out of service. Due to the combination of all of these challenges, a unique inspection solution was required, in order to complete the project successfully.

Since Intero's Pipe Explorer robots are tetherless, battery-operated, and wirelessly controlled, there is a finite distance they are able to inspect before they must be recharged. In lieu of numerous size-on-size hot tap fittings, periodic recharging stations were added to the pipeline, which allowed the Pipe Explorer robot to be recharged while it remained in the pipeline which significantly reduced the number of times the Pipe Explorer robot would need to be removed from the pipeline. The pipeline operator and Intero jointly identified 13 sites that were required along the pipeline length, while the pipeline operator worked with the landowners and their farmland to determine the optimal locations. Special consideration was given to how far equipment would need to travel over farmland, as rain and mud could make excavations inaccessible.

Robotic Pipeline Inspection

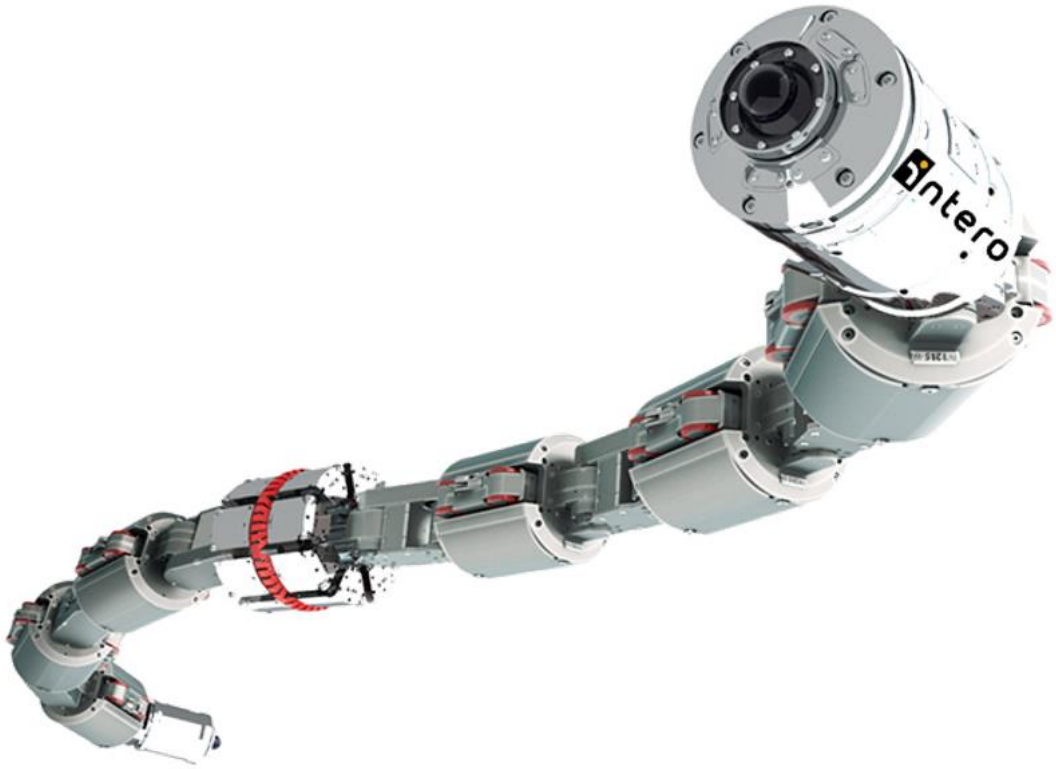

Figure 2: Explorer 10/14

Since the pipeline to be inspected was 10-inch diameter, the multi-diameter capable Pipe Explorer 10/14 (suitable for 10”, 12”, or 14” pipelines) was chosen to inspect the Brandon lateral, an example of which is shown in Figure 2.

Unlike a traditional free-swimming inspection tool, Pipe Explorer robots are driven remotely by an Intero operator. Communication is maintained with the Pipe Explorer throughout the entirety of the inspection and the Intero operator is able to control where the robot travels, how quickly it moves, and a number of other operational features with real-time feedback on how individual components of the robot are functioning at any point of the inspection. Should the robot operator come across any previously unknown feature in the pipeline, the feature can be documented in real time and – depending on the severity of the feature – the decision whether to continue or turn back can be made. A view from the inside of one of the hot tap fittings is illustrated in Figure 3.

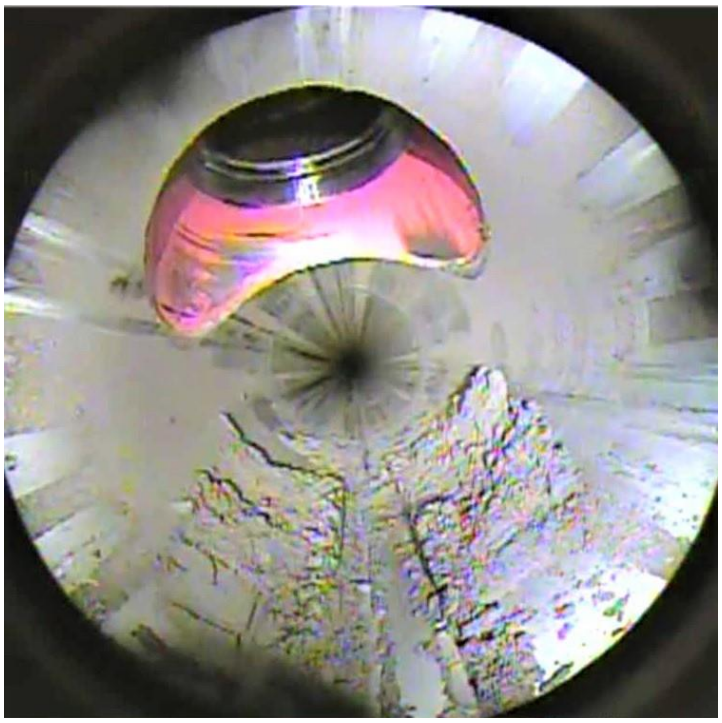

Figure 3: 254 mm (10 inch) hot tap Fitting

In order to address pipelines which do not have existing launchers and receivers the Pipe Explorer robots have been designed to launch through size-on-size hot tap fittings. In the case of the Brandon lateral, the pipeline operator installed four of these hot tap launch and receive sites over the entire length of the 8.3 km pipeline. Intero operators have the ability to either launch and receive from a single fitting (Out-and-Back) or launch at one site and receive at another (Point-to-Point) so, given the overall length of the line and the fittings that were installed on the pipeline, both methods would be utilized on the project. As outlined in Figure 4, Intero's Pipe Explorer 10/14 was launched and received at the same location one time at the east end of the pipeline and the remainder of the inspection was completed by travelling from launch site to launch site.

Figure 4: Schematic of Brandon Lateral

Since Pipe Explorer robots are battery powered, their initial inspection range is limited by the range capacity of the batteries on the unit. In an effort to extend the range of the Pipe Explorer fleet beyond this initial run, Intero implements a proprietary in-line charging (ILC) system which, in effect, adds “refueling” stations for the robot along the pipeline. Since these ILC points are smaller openings and require lighter fittings, the number of more costly size-on-size hot tap fittings can be reduced and the overall inspection time can be reduced from having to exit the line every time the batteries need recharging. In total, nine inline charging sites were utilized during the Brandon lateral inspection. An example of an ILC site is shown in Figure 5.

Figure 5: In-line Charging Site on 10 inch Pipeline

By utilizing this specialized in-line charging technology, pipeline operators are able to execute longer robotic inspections than would otherwise be possible. In the case of the Brandon lateral, the pipeline operator was able to leverage Intero's ILC such that the larger launch system, outlined in Figure 6, would be minimized to four locations on the line, resulting in reduced capital expenditure and a total onsite time of only nine days.

Figure 6: Intero's Launch System for Pipe Explorer 10/14

Intero's Performance and Data

Whenever launching into a pipeline that has never been inspected, the conditions of the pipeline are – understandably – unknown. Whether complicated by the lack of pipe cleanliness, unknown geometry, or even malfunctioning inspection equipment, collecting high-quality data has always proved challenging in these situations. For the Pipe Explorer MFL robot, many of these challenges are mitigated by being able to see the conditions of the pipeline and control the robot in real-time. While executing an inspection, live video, MFL data, and deformation data are transmitted to the operator which allows them to make on-the-fly informed decisions about tool passage and data collection quality.

For the Brandon lateral, once the inspections began, the line was found to be quite clean, with minimal debris inhibiting the Pipe Explorer's navigation of the line. Over the course of the 8.3 km inspected, the Pipe Explorer averaged over 99% for MFL and LDS data coverage respectively. In addition to the integrity data gathered, previously unknown taps and bottom-out fittings were discovered within the pipeline.

Finally, in order to provide added confidence to stakeholders, the pipeline operator produced a validation spool – with added defects to their own specification – which was scanned by the Pipe Explorer robot prior to starting the inspection. As a result, the pipeline operator and Intero were able to use this validation information as a reference for interpreting the data from the full inspection.

Summary

While the nine-day inspection of the Brandon lateral was successful and provided the pipeline operator with high quality MFL, Laser Deformation, and Video data with over 99% coverage of the pipeline – data that the operator would not have otherwise been able to acquire – many of the pipeline operator's challenges and costs came from adding the multiple fittings required by the Pipe Explorer robot and charging equipment. As Intero looks to the future, in order to reduce the required number of fittings on the pipeline, the range of Pipe Explorer robot must be extended and multiple initiatives are underway to both reduce the energy demands of the Pipe Explorer, as well as to optimize the In-Line Charging process to prove less impactful to the inspection's surroundings.