INSPECTION METHODOLOGIES AND TRADEOFFS FOR INSPECTION OF UNPIGGABLE PIPELINES

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Abstract

Recent high-profile pipeline failures have focused increased regulatory scrutiny on the integrity assessment and management of pipeline assets throughout the world. This increase in scrutiny is even more pronounced for pipelines deemed “unpiggable.” While a lack of launcher and receiver facilities and limited line flow are obvious challenges, other pipeline design issues ranging from unbarred tees, to multiple diameter step changes, and even mitered or small diameter bends have historically provided inspection difficulties.

Modern advances in inspection technologies now allow for inspection and assessment of these previously unpiggable pipelines providing today’s owner-operators a varied range of inspection options. However, not only does each inspection methodology have its own related costs and benefits, but each option can have a significant and varied impact on the entire asset integrity program.

This paper uses multiple case studies to highlight solutions that have worked for individual operators. By examining the results of various inspection methods and detailing how inspection data is used for assessment and asset management, we can understand how inspection data ties into the larger decision making process.

Main Paper

Recent high-profile pipeline failures have focused increased regulatory scrutiny on the integrity assessment and management of pipeline assets throughout the world. While many piping systems have historically been deemed “unpiggable,” advances in smart pigging and other inspection technology now allow for inspection of these lines. While regulatory compliance may be achieved by hydrotesting some lines, this testing does not provide a complete picture of the condition of a pipeline to assist in predictive maintenance as part of the operator’s integrity management program.

In-line inspection now allows operators to gather a large amount of inspection data about systems on which they previously were able to obtain very little or incomplete information. In addition to collecting information about more systems, the quality and resolution of the available data is also increasing. Many modern high resolution inspection technologies may accurately size the length and depth of a flaw, but it is now possible to go beyond the older assessment methodologies and run Level 2 (Effective Area) assessments on areas of metal loss or build finite element models of individual dents in order to demonstrate fitness-for-service.

Competing inspection technologies can be evaluated not only by comparing the cost of inspection, site preparation and mechanical set-up, but also by examining what can be done with the data after the inspection. Discussions of in-line inspections often focus on the details of the data quality, precision of measurement and statistics about flaws of a variety of depths. These are important and easily quantifiable data, but for a pipeline operator the most crucial decisions come down to the ability to safely operate the pipeline and to spend maintenance budgets efficiently. Gathering a high quality data set from an inspection allows for better planning and overall management of a pipeline system.

With unpiggable pipelines, not only do the standard concerns about data quality arise, but further concerns such as the mechanical work required to make a line piggable, the effort required to clean a line, and potential issues about accessibility of the line for repairs can play a larger role as well. As unpiggable lines, by definition, have not historically been pigged, the mechanical and operational setup required for an in-line inspection demands significant attention. The owners of some unpiggable pipeline systems may not have the extensive experience with pigging programs that some of the larger traditional operators have. Whether it is replacing small radius bends or reduced port valves, or the addition of launcher and/or receiver facilities, mechanical work can quickly add complexity and cost to an inspection project. Even the inspection medium itself can pose a challenge. If an inspection is not able to be carried out with the pipeline in service, handling and disposing of the potentially large volume of water, or other fluids, must be considered in planning the inspection. An inspection tool that can simplify the inspection process will quickly reduce the overall cost of the entire project.

The logistical challenges operators face can pose significant hurdles as well. Incomplete records and unknown information about a pipeline often require an operator to make conservative decisions about what type of tool can be run, or whether an inspection run is even possible. Mapping information about the configuration and location of the pipeline can prove as beneficial as the detailed reports on defects and anomalies within the line. In addition, increased ease of mobilization and operation during the in-line inspection can provide additional benefits by reducing the burden to an operator's Health, Safety and Environment department. The ability to have a successful first inspection of a complex piping system that has never been inspected is of great operational benefit.

The importance of a high resolution data set has become increasingly clear. Not only does such data allow an operator to draw a more complete picture about the state of the pipeline and what damage mechanisms may be involved, but precise direct measurements allow an operator to make more accurate decisions about remediation, inspection frequencies, and corrosion growth rates. In addition, for pipelines with restricted or limited access, high resolution data allows for further assessment of defects and damage mechanisms using methods such as finite element assessment or advanced statistical modeling. These advanced assessments provide the operator with greater value from each individual inspection.

Prove-up and repair digs in dense pipeline corridors and urban areas are complex logistical projects. The ability to avoid digs caused by an overly conservative assessment methodology can save an operator money that could be used on other inspection or remediation projects. Unnecessary repairs can lead to an integrity management program that is not conservative because finite resources are diverted away from areas or projects where they could be more useful. High-resolution data allows for an integrity program which can correctly identify and prioritize the highest priority defects, and the rapid delivery of such data can allow an operator to take action while a line is still out of service.

Case Study -1

A pipeline operator needed to inspect a pipeline running through a major metropolitan area. The pipeline had been constructed in various phases over time and contained numerous transitions from 6" to 8" and back again. Several previous attempts at inspection had failed and the operator was left with hydrotesting as their only option for regulatory compliance.

Hydrotests only provide a snapshot of the condition of a pipeline and are not useful in finding dents or small corrosion areas that do not impact the pressure carrying capacity of the line. Even areas of nearly through-wall corrosion can pass a hydrotest only to fail in service a few months later. The accuracy of inspection data was important to the client because of the high cost of prove-up digs at many of the locations along the length of the line.

Quest Integrity Group developed a dual diameter 6"/8" tool that navigates the small radius bends present in the line while collecting radius and thickness data on both the 6" and 8" sections of pipe in a single inspection. By working collaboratively with the operator throughout the design and inspection process, Quest Integrity was able to ensure that the tool would navigate the line, and designed and tested the tool using the actual available pump information. To facilitate this effort, Quest Integrity made multiple mobilizations on the project running both a sizing and inspection tool. As a result, the inspection was successful on the first run of the InVista™ tool and over 32 miles of high-resolution ultrasonic data was collected.

This high-resolution inspection data allowed provided the operator with a more complete picture of its pipeline. Not only was previously unknown third party damage discovered, but information about the original construction of the pipeline could also be seen in the data. Previously unknown schedule and weld type changes were observed, and all features were then mapped to known above ground locations.

A full fitness-for-service engineering assessment was delivered for the entire 32-mile length of the pipeline and hundreds of individual anomalies were sized and identified. A prove-up program commenced to repair critical anomalies and to develop statistical confidence in the inspection data for this run. Quest Integrity and the operator worked together in locating and investigating anomalies in the most cost effective and time efficient manner.

With high level data from a successful inspection, the operator can now address issues with this pipeline before they become significant problems, thus being proactive instead of reactive. In addition, the cost savings from subsequent hydrotests can instead be more efficiently redirected to other integrity management projects.

Case Study – 2

A terminal operator had a set of parallel pipelines that ran under a short span of a navigable waterway. The lines had no launcher or receiver facilities and were in an area where space for setup of any pigging equipment was at a premium. Guided wave ultrasonics had been used previously on the lines, but no pigging for either cleaning or inspection had been done. The operator wanted more detailed information about the current condition of the line than their current inspection program was able to deliver.

A variety of options were considered for the inspection, all of which required some mechanical work. One option was to break the lines at a flange on either side of the waterway and pull a Magnetic Flux Leakage (MFL) tool through each of the lines. Another option was to add a launcher to one end and a receiver to the other and push an inspection pig through the line. In both cases, there were flanged joints of pipe on either end that could be isolated by existing valves.

When considering the available inspection options, the operator took into account the total amount of mechanical work required for each inspection methodology, as well as the ease of operation. Quest Integrity simplified the project for the operator by providing the required launcher barrel and performing the cleaning of the pipeline as part of the contract, in addition to providing a high quality ultrasonic dataset.

The InVista tool's bidirectional capability further simplified the project for the operator. Therefore, a single launcher/receiver barrel could be used, and the impact on the far side of the water crossing would be minimized. A single temporary launcher/receiver barrel was used for both the cleaning and inspection of all four lines. While this barrel was unbolted from each of four separate laterals and reattached to the next one, data was downloaded from one run and the InVista tool was prepared to run the next line. The efficiency and full service offering made the ultrasonic inspection very price-competitive.

In addition to the operational cost-effectiveness and benefits, high quality data was collected and a full fitness-for-service report was delivered to the operator as part of the standard deliverable. Quest Integrity reported areas of corrosion and made recommendations about corrective actions in the report. Furthermore, a dent greater than 6% was discovered in the line. Although the dent was difficult to access, further engineering assessment was performed using the detailed inspection data to demonstrate the fitness-for-service of the line inclusive of the dent.

Case Study-3

An operator had a 6" pipeline on a wharf that was used for transporting crude oil from a marine terminal to its refinery. In such a critical area, the potential cost of any loss of containment would be very high. Any extensive mechanical work to this line would increase the risk of loss and the potential damages and costs because of the environmental sensitivity of the area. The line had no existing launcher or receiver facilities and did not have a regular cleaning program. However, there were sections of the pipeline which were set-up with flanged connections near valves, which could be used to control the flow and isolate these particular sections. By taking advantage of these flanged connections, an InVista ultrasonic pipeline inspection was carried out on the pipeline with no mechanical alterations to the pipeline. The InVista tool was launched and received in nominal sized pipe at a single location accessed directly by the flanged joint. A flanged connection was unbolted, and the InVista tool was inserted into the pipeline at this opening by hand. At the receiving end, an orifice plate was inserted and the flanged connections were then re-bolted and the previously opened portions of the line were refilled using the plant's fire water. Once the line was again completely filled, local valves were opened and the tool was launched and successfully inspected two miles of pipeline.

The tool was propelled at a low pressure in the plant's fire water. Since the InVista tool is lightweight and easily transportable by one person, no heavy lifting equipment was required to get the tool into the middle of a congested piping area or to place it into the pipeline, easing health and safety concerns and the logistics of the project. At the far end of the inspected pipeline, once the transmitter signal from the InVista tool confirmed its arrival, the pipeline was again opened and in less than fifteen minutes, the InVista tool was removed by hand from the pipeline.

At the completion of the inspection, the data was analyzed and a full fitness-for-service assessment was prepared for the entire inspected length of the pipeline. In addition, rapid analysis of the data while the inspection team was onsite allowed the operator to perform additional hand held inspections to verify the signatures seen in the inspection data on key portions of the line while the pipeline was still out of service.

Case Study-4

A refining operator had a set of liquid pipelines in a major metropolitan area for which they were doing a large inspection and remediation project. As part of their project preparation, it was determined that some of the 4" and 10" pipelines contained several mitered bends. The client was concerned about problems with inspecting these mitered bends because they had previous experience with pigs becoming lodged in the miters.

Quest Integrity Group was able to demonstrate that the InVista tool navigated mitered bends. In addition, the bidirectional capabilities of the tool gave the operator additional confidence that it would not become lodged at one of the miters. The InVista tool successfully inspected 100% of the required pipelines, including lines which were not fully cleaned because of difficulties that the cleaning pigs encountered while attempting to navigate the full length of the line.

The operator made the inspection of multiple lines more efficient by looping pipelines of different service types, but of the same diameter together. In addition, it was revealed after the project that the operator had also machined small external flaws into the loop piping, and could use these known flaws as part of the process for validating the performance of the inspection tool.

The inspection data was also validated with more traditional means. Significant small diameter internal pitting data was detected by the InVista tool in a section of the pipeline where data quality was less than optimal due to difficulties in cleaning. Although the cleaning pigs had difficulty navigating this section of the pipeline, the InVista tool was able to navigate smoothly and gather data. Despite some data degradation due to particulates and debris remaining in the line, the tool was able to identify areas of the pipeline with a large amount of small diameter internal corrosion. The locations and severity of the worst areas of this pitting were rapidly delivered to the operator in an expedited preliminary report and Quest Integrity personnel were present when these areas were excavated and further inspection was performed. This service ensured that operator resources were utilized efficiently during the prove-up process, while Quest Integrity's served in ensuring that the correct sections of the pipeline were examined. This collaboration between the operator and the inspecting company allowed for efficient decision making as well as valuable confirmation of the raw data signals interpreted by Quest Integrity's analysts.

As part of the Quest Integrity Group's standard fitness-for-service engineering assessment on the line, the most significant of the individual pits were identified, in addition to the relative integrity of the individual pipe joints was included in the final report. This complete report gave the operator an accurate and actionable view of the pipeline's integrity with the delivery of the pipeline data.

Summary

Unpiggable pipelines present a unique set of challenges, but benefit from high resolution direct measurement as much as, if not more than, lines that are conventionally piggable. Difficulty in access puts a premium on ease of inspection as well as on accurate, actionable data and assessment. Sometimes, it is the high-level assessment of the data that can be of greatest benefit to the operator of an unpiggable pipeline.

While a hydrotest may achieve regulatory compliance for a pipeline, this compliance alone is not an assurance of safe or cost-effective operation. By gaining the detailed inspection data an ILI tool can provide, an operator is able to be proactive rather than reactive in their integrity management plan. This knowledge allows for better planning of inspection frequencies, corrosion growth analysis as well as repair and mitigation plans. Thus a high resolution dataset allows for increased overall cost savings which can be used to enhance the overall operational integrity of the entire pipeline system.

It is important to evaluate an inspection as part of the larger overall integrity management plan. An in-line inspection is but a small part of a larger overall project. Ease of setup for getting an in-line inspection tool successfully through the line, ease of operation for conducting the inspection and the power of a high resolution data set that enables a complete fitness-for-service assessment are all part of a larger, overall more efficient integrity management program.