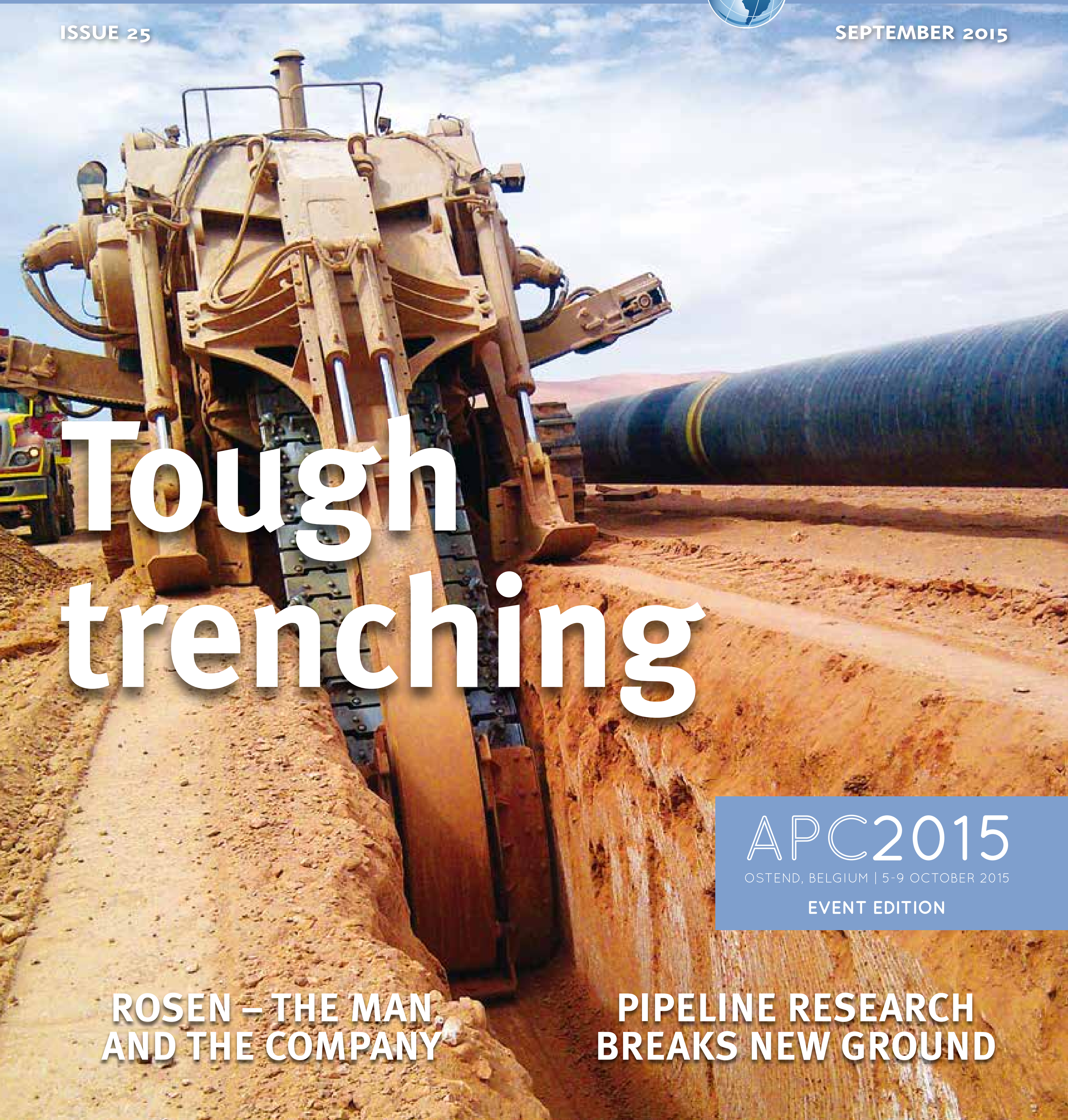
PIPELINES INTERNATIONAL

ISSUE 25

SEPTEMBER 2015



Tough trenching

APC2015

OSTEND, BELGIUM | 5-9 OCTOBER 2015

EVENT EDITION

ROSEN – THE MAN AND THE COMPANY

PIPELINE RESEARCH BREAKS NEW GROUND

- Exhibit the same sizing accuracy regardless of:
  - » radial location of features; and
  - » whether or not a feature is located within external corrosion;
- Size the depth of up to 98 per cent of reported features within the tool specified +1 tool tolerance; and
- Provide measurements resulting in accurate to conservative predicted failure pressures for up to 99 per cent of the reported features.

These findings demonstrate that the latest generation of conventional ultrasonic crack detection tools have the capability to enable pipeline operators to effectively manage the threat of cracking along their pipeline systems. However, it is important that tool strengths and limitations are understood to ensure appropriate usage, and that a comprehensive overall crack management programme is in place to support validation of each ILI run. Continuing research and collection of performance data will increase confidence in the technology and its potential applications.

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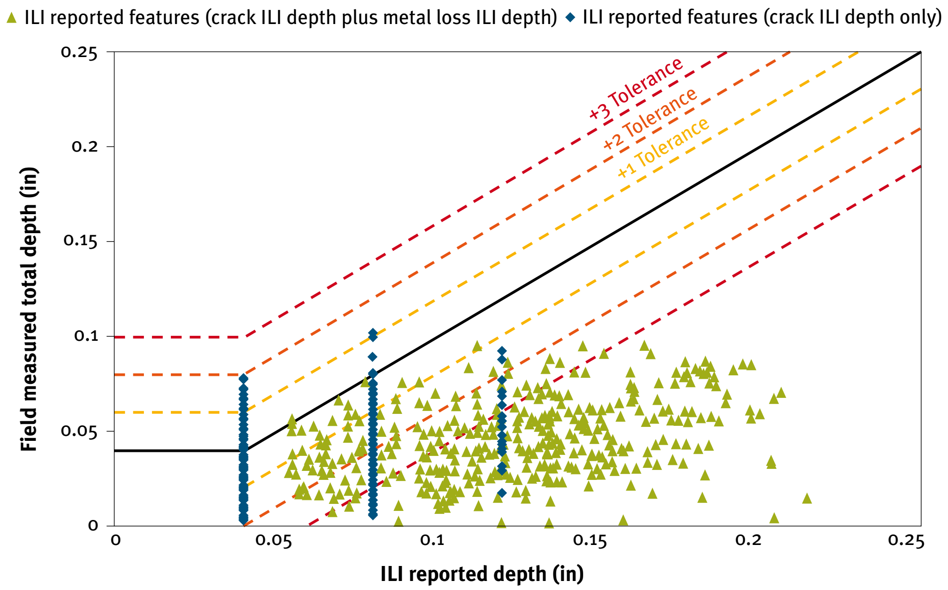

Figure 6: Feature depths (with and without metal loss ILI depth included).

This article is the first of a series of three to be published in *Pipelines International* detailing Enbridge's experience with best-in-class inspection technology. Details of the remaining articles in the series, to be published in the December 2015 and March 2016 editions, are below:

Effective implementation of a crack in-line inspection programme

As part of a comprehensive crack management programme, ILI tool runs undergo a validation process to assess performance. In some cases, re-analysis of the raw data is required to learn from and mitigate ILI miscalls identified in the original ILI report.

This article examines a liquids transmission line that underwent a crack ILI programme that included such a process. Supported by excavations, the associated field NDE-ILI correlations were used to validate the ILI runs. A hydrostatic test was then completed, and its successful outcome confirmed the effectiveness of the crack management programme for the pipeline.

Reliability engineering: a target-driven approach to integrity management

In the past several years, Enbridge has gathered an extensive amount of data from ILI, investigative excavations, pipe replacements, and hydrotests. The collation of this evidence, and the analytics that have followed, have resulted in a 'data-driven' model using principles of reliability engineering to advance pipeline safety.

This methodology allows pipeline conditions to be objectively assessed in terms of the level of remaining uncertainty by using probability statistics that are benchmarked against historical incident data. The effectiveness of additional measures such as hydrotesting can be quantified, allowing operators to determine actions within an overall IMP decision framework in order to meet required thresholds of safety.

PIGGING

Overcoming inspection challenges using non-traditional ILI

By Robert Liddicoat, Lead Project Manager, Gas Transmission Systems (GTS), Walnut Creek, California, USA

This paper was presented at the Unpiggable Pipeline Solutions Forum held in Houston in May 2015, organised by Clarion Technical Conferences and Tiratsoo Technical.

Emerging non-traditional (NT) in-line inspection (ILI) technologies are providing new solutions for pipeline operators to inspect and gather critical-asset data at pipeline locations not previously accessible by internal inspection tools. These methods and tools have proven useful to complete integrity management inspections at targeted locations, and for identifying and pinpointing internal pipeline features in support of in-situ hydrostatic tests and asset-knowledge requirements. Successful NT ILI projects require a detailed understanding of the unique project constraints, the selection of the appropriate execution method and NT ILI tool, and meticulous planning and coordination.

Non-traditional ILI (NT ILI) refers to the internal inspection by means other than traditional free-swimming ILI tools deployed from established launcher and receiver facilities. Numerous inspection challenges can be overcome with the correct application of NT ILI methods, making these techniques and tools a valuable addition to the pipeline operator's toolkit. The perspectives offered below are based on experience gained executing more than 30 projects using multiple NT ILI execution methods and tools.

Pipetel's Explorer untethered robotic MFL tool ready for deployment into pressurised pipeline as part of a project to inspect multiple inserted pipe segments in a major metropolitan area.

Drivers and objectives

Drivers for NT ILI projects generally fall into one of two main categories: integrity management inspections, or identification and/or location of pipeline features.

NT ILI has proven beneficial in completing integrity-management inspections on pipeline segments with inspection challenges that would otherwise require high-cost construction excavation, or in some cases are impractical for excavation, such as at water crossings, cased spans, cased crossings of railways and roads, installations in bridge structures, and other inserted pipe sections. NT ILI also provides a solution for short pipeline segments that are not practical for traditional ILI, but where the operator desires or requires data to assess the condition of the asset.

Additionally, NT ILI can be used to identify and pinpoint exact locations of pipeline features such as internal drips, reducers/fittings, and other appurtenances. This information may be used to support the operator's asset knowledge, repairs, or in the design of in-situ hydrostatic tests.

Project scoping

Evaluation of potential NT ILI projects starts with a clear understanding of the goals and objectives of the project. The first step in scoping is to identify if it is an integrity management inspection for a specific anomaly type, or an informational-gathering effort to pinpoint pipeline features. These questions impact the type of tool and non-destructive examination (NDE) technology to be used to gather the desired data, i.e. magnetic-flux leakage (MFL) vs electro-magnetic acoustic transducer (EMAT) vs high-resolution video. The extent of the required inspection coverage must also be defined at the start. Based on the tool and execution method selected, the inspection may be expanded beyond the targeted inspection location in order to maximise the capabilities of the tool and to obtain additional inspection data.

The blue line represents location of a cased span (a 10 inch diameter pipe inside a 16 inch casing) contained inside a bridge structure at a river crossing inspected with an untethered robotic MFL tool while the pipeline remained pressurised and in operation. The NT ILI tool was also run in the opposite direction away from the bridge in order to eliminate the need for additional ECDA excavations in the area.

Baker Hughes' V-Line tethered MFL tool being loaded into pipeline to inspect 518 m up a mountainside in an environmentally sensitive area.

Diakont's RODIS tethered robotic EMAT tool was used to complete a direct assessment casing inspection delayed by changed permit conditions. NT ILI was deployed and completed the project six days after initiation by inserting the tool outside the disputed permit area and coordinating the outage with a nearby replacement project.

Use of aerial imagery is employed to identify potential entry points for tool insertion and other excavations required for project execution. Multiple locations, preferably both upstream and downstream from the target area, should be identified, taking account of the ability to safely execute the project, and the lead times necessary to secure approval(s) for the access point through land negotiations, permitting, and agreements required to meet the project deadline. Consideration should be given to the impacts on local residents, construction logistics, traffic control, workspace constraints, gas blow-down, and other construction noise related to the activities at each site.

Pipeline geometry must be evaluated for diameter, wall thickness, inspection length, bends, and internal features that will affect the viability of various NT ILI execution methods and tools. This information must be considered in relation to the target inspection area in addition to the identified tool insertion point(s).

Pipeline and system conditions must be evaluated and take into account the feasibility and requirements to perform a pipeline shutdown. In addition, an evaluation is performed to determine the potential for liquid and debris in the pipeline that have the potential to affect the performance of the NT ILI tools.

Based on evaluation of the data gathered, potentially viable NT ILI methods can be identified, and the appropriate vendors contacted to confirm the project's feasibility and the tool availability for the scheduled project window.

Execution methods

There are multiple methods of conducting NT ILI projects, with no single method being suitable for every project scenario. Each of the NDE technologies has specific considerations that must be taken into account when deploying them. Types of NDE sensors deployed or considered for the projects which serve as the basis for this report include MFL, EMAT, eddy current, laser deformation, and ultrasonic. In addition, high-resolution cameras have been used effectively to pinpoint pipeline features in combination with the ability of tools to record the distance travelled to the feature location. There are multiple delivery platforms available that deploy the tools through the pipeline, including tethered robotic, untethered robotic, tethered MFL (tethered pig), and the use of traditional free-swimming tools deployed at targeted locations. All methods have unique requirements that must be considered during project planning. Tools launched from a single entry point may be deployed in both directions in order to maximise inspection coverage based on the capabilities of the particular tool and the specific pipeline configuration. Many tools also are equipped with high-resolution cameras which can provide a video recording of the pipeline as part of the project report.

Tethered robotic tools, which require the pipeline segment be taken out of service, can be launched through a single pipeline cut-out at the entry point, and can traverse the pipeline in both directions. The distance travelled in the pipeline is a factor of the quantity and degree of bends traversed, in addition to the tool's tether length. Additional considerations, such as pipeline cleanliness

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and elevation changes, are factors that impact the capability of the tools to traverse the pipeline segment.

Untethered robotic tools can also be launched from a single entry point, and can be deployed in a pressurised pipeline through a pressure-control fitting (PCF), or in a depressurised pipeline through a cut-out. These tools use on-board batteries for power, and antennas for tool communication and data transmission.

Tethered MFL tools, also referred to as tethered pigs, can be used in either a bi-directional or uni-directional manner. In a bi-directional operation, the tool is launched and retrieved from a single entry point via a cut-out, propelled away from the launch point with compressed air, and then pulled back via its tether and a winch. In a uni-directional operation, the tool is pulled between two cut-outs. The feasibility of these types of projects is generally dictated by bend radius, bend degree, and total bend quantity within the project scope.

In some cases, using traditional free-swimming ILI tools deployed via a temporary launcher and receiver installed in the field to inspect targeted locations offers the most viable option. This method is more resource-intensive than methods that use a single entry point; however, the method may offer greater schedule flexibility given the larger number of vendors and tools available than with robotic tools, in particular in the smaller diameters (6-8 inches). Advances are being made by robotic vendors to expand the capabilities of robotic tools within this range.

Project planning and coordination

Given the complexity of conducting NT ILI projects, meticulous planning, coordination, and communication is required to ensure project success. A comprehensive project team will include project management, ILI engineering, design engineering, construction (excavation, welding, ILI vendor support), permitting, land/environmental, gas system planning, gas outage planning and customer and governmental relations, and discussions with the other stakeholders identified in the project plan.

Detailed site planning, including a site walk, is essential to confirm the assumptions made during the initial project scoping in order to identify excavation and workspace locations, and outline permitting requirements for each site. Planning for each location must consider what activities are required during the various phases of the project's execution.

In addition to establishing a schedule, a detailed task list is important to capture all the critical project details, assign roles and responsibilities, and drive key tasks to ensure the project schedule is met. With multiple support groups involved and advanced NT ILI technologies mobilised to the project site from across the country or internationally, ensuring that all the details are meticulously planned, and the necessary tasks completed, is of paramount importance to a successful project execution.

Project risks should be identified and contingency plans established during the planning phase. Common risks such as emergency tool extraction, an incomplete inspection, or discovery of an anomaly requiring a rapid repair response, must be built in to the project plan. Contingencies are developed for each scenario, agreed upon by the team, and communicated to key stakeholders in advance in case a contingency condition is encountered.

Project execution

A detailed project plan is important to ensure clear understanding among the execution team, given that it is composed of multiple groups. The project plan includes the project description and summary schedule of key milestones, a team roster with roles and contact information, the contingency plan, and a detailed sequence of operations. The sequence of operations covers daily site activities, details of individual tasks, details of responsible personnel, arrival times, identification of what equipment and materials are to be supplied and by whom, as well as key safety details.

Key project team members, including the ILI engineer and the project manager, should be scheduled to be on site in the event that changes to the project plan are necessary based on site conditions, and in order to ensure that any of the changes that are made take account of the overarching project goals and project requirements.

Conclusions and outlook for future use

NT ILI has proven to be a valuable tool in completing inspections and gathering key pipeline data in challenging pipeline locations where previous methods have proved infeasible or impractical.

Given the multitude of potential project scenarios and unique conditions and constraints, no single NT ILI tool or execution method is appropriate for every situation. Each project must be thoroughly analysed to ensure that project conditions are identified and matched with the method and tool that can provide the optimum solution.

Rigorous project management must be applied due to the high level of complexity, detail, and nuances involved with the various execution methods. A well-planned project has a greater chance of success; however, projects do not always go as planned, and thus a thoughtful framework must be established for contingencies.

Using non-traditional ILI methods, operators can make the 'non-piggable' achievable through innovation and a can-do approach to project planning and execution.