ILI WITH A *tethered tool*

Lance Wethey, Technical Solutions Specialist, ROSEN, USA, discusses inline inspection of unpiggable natural gas pipelines without service interruption.

Inline inspection (ILI) has been a critical component of pipeline integrity management for decades. The perpetual innovation of inline inspection tools has allowed pipeline operators to assess the material condition of largely buried pipelines with minimal interruption in service. Free-swimming ILI are introduced into pipeline systems and then propelled by the pipeline's product flow, gathering valuable data that is reviewed to identify various threats such as metal loss associated with corrosion and external damage. Guided by the resultant inspection defect reporting, pipeline operators can then address these concerns while accommodating efforts to maintain product delivery as well as preventing environmental and life-threatening releases.

Since pipelines existed before the introduction of ILI tools, many pipelines had to be retrofitted to accommodate this inspection method, while newer pipelines are constructed with allowance of ILI incorporated in the initial design.

The first natural gas pipelines to enjoy the benefit of ILI were primarily large diameter transmission and distribution assets. Over time, as regulatory requirements expanded, operators sought to inspect additional pipelines, which were once deemed 'unpiggable'. These included pipelines that had varying diameters, as well as operating conditions that were not compatible with the currently available ILI tools. The industry responded to the demand and developed ILI tools capable of inspecting varying pipe diameters in a single inspection. Further developments included low-friction ILI tool configurations, reducing the differential pressure needed to propel the ILI tool through challenging pipe geometry thereby improving ILI tool inception behaviour in low pressure systems.

Figure 1. Testing and validation is a key element to the development of new ILI technologies. This image shows the 1.5D 90˚ back-to-back bend test set-up.

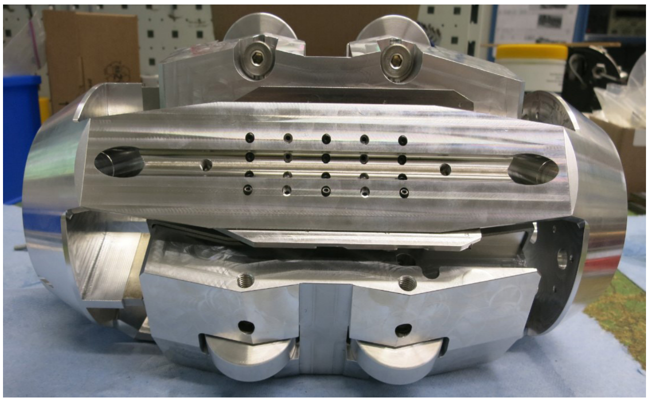

Figure 2. The newly developed 8 in. tractor segment.

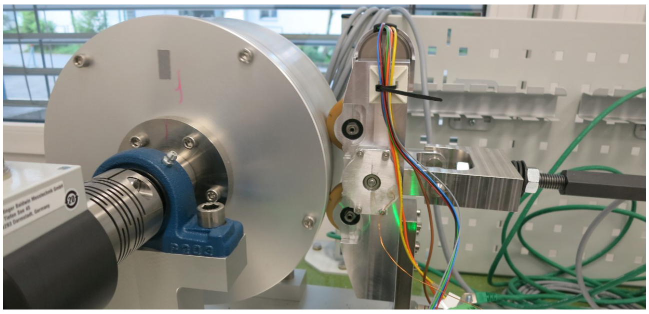

Figure 3. Dynamometer testing of wheel friction is done to ensure grip to the pipe wall.

Essentially, many pipelines were steadily being stripped of their 'unpiggable' moniker due to continual innovations of ILI tool designs.

Integrity management demands continue to increase for pipeline operators, thus requiring the capabilities of ILI tools to grow to mitigate the reliance upon assessment methods that involve service interruption such as hydrotesting. In other words, more unpiggable pipeline challenges must be overcome.

Operating conditions not suitable for free-swimming ILI tools create a challenge

Natural gas pipelines that deliver gas to customers such as electricity generating plants, factories, and even city gate stations rely upon on a 'line-pack' delivery method. This involves the operating maintaining a certain volume of natural gas in a particular segment by 'packing' the pipeline to a specific pressure range. As customers draw gas off the line, more gas is introduced from an upstream transmission supply. The pressure limit can be defined by numerous factors, such as customer requirements or even regulatory stipulations. These factors produce transient operating conditions that are incapable of gas pressures and flow rates suitable for propelling a free-swimming ILI tool.

If an ILI tool cannot rely upon the product stream for propulsion through a pipeline, alternative methods must be considered if ILI remains the assessment method of choice.

Considering self-propelled robotics and tethers as a solution

Commercially self-propelled robotic axial magnetic flux leakage (MFL-A) ILI tools have existed for more than a decade that are capable of navigation through pipelines and gathering inspection data. The ILI tool is inserted into the pipeline and driven by a tool operator aided by video feed. Furthermore, both wired (tethered) and wireless options exist, each with their own pros and cons. However, options are currently limited if a natural gas pipeline is to remain in-service during inspection. In particular, tethered ILI solution availability suitable for pressurised natural gas pipelines are lagging behind progresses already achieved with wireless solutions.

A question that automatically arises when considering tethered robotic ILI tools is, "Why even be concerned with pursuing a wired option if wireless is available?" The answer can depend on the pipeline targeted for inspection. A wireless option may very well be perfectly adequate in many situations, while a tethered option may offer additional contingencies if the need arises.

One of the primary advantages of a tethered ILI solution is recovery potential. In the event an ILI tool becomes stationary due to pipeline influence such as debris or mechanical failure of the ILI tool itself, extraction may be facilitated by pulling the ILI tool back to the insertion point. Additionally, wired ILI tool communication is not subject to external attenuation or interference thus ensuring reliable communication. Power constraints are also mitigated. Restrictive pipeline features such as bends with elevation change or uphill travel require more energy to traverse. With a tethered ILI, energy capacity challenges are eliminated, especially if a difficult pipeline obstacle requires numerous attempts to traverse.

This discussion would not be complete without also considering potentially negative aspects of tethered robotic ILI solutions. The tether itself introduces certain limitations that must be recognised before being selected for any specific inspection effort. For example, an excessive number of tight radius pipeline bends can increase the friction applied to the tether and limit inspection distance. Also, feeding a tethered element into a pressurised pipeline requires a special apparatus to contain the natural gas and mitigate leakage.

A pipeline operator must weigh all the advantages and disadvantages of available self-propelled robotic ILI and consider which optimally suits their requirements. It is the responsibility of ILI vendors to produce as many options as possible to assist the operators with their integrity management efforts.

ROSEN is currently expanding the portfolio of self-propelled robotic solutions available to natural gas operators who need to avoid service interruption. Currently, the prioritisation is focused on the advantages of a tethered solution. This development will produce MFL-A and MD (geometry) inspection technologies for pressurised 8 in. natural gas pipelines. The scope includes the ILI system with accessories for pipeline insertion and pressure containment.

8 in. tethered self-propelled robotic ILI system

- The MFL-A measuring segment will be an iteration of ROSEN's low-friction magnetisers. Typically, ILI magnetiser units represent the most restrictive element that requires the most energy to propel through pipeline fittings such as bends. It must involve the necessary mass to achieve sufficient magnetisation of pipe wall, while remaining sufficiently collapsible to navigate tight right radius bends such 1.5D 90° fittings. The friction-reducing aspects reduce drag and thus minimise the required towing force. The MD segment will utilise contactless eddy-current sensors that determine internal pipeline diameter by measuring the 'lift-off' response in the sensor coils. This method is resistive to debris influence since it relies upon electromagnetic field induction in ferrous material (pipe wall).

- The tractor(s) that tows the ILI system will incorporate aluminium wheels mounted on an active suspension system that can be applied against a pipe wall with an adjustable force. This allows for situations in which the ILI tool may need to ascend and descend vertical segments that require a stronger grip against pipe wall.

- A front mounted camera exists to offer a real-time visual feed to the ILI tool operator as the tool is driven through the pipeline. This is crucial since unexpected challenges may arise during inspection such as wall thickness changes or tee installations. In such a scenario, the tool operator can make any necessary adjustments to the tractor to accommodate traversal.

- The ILI tool will be tethered to an umbilical winch system that supplies power and fibreoptic communication. The current specified cable length is 2.5 km (1.54 miles). The expected length of the type of pipelines targeted for this solution are anticipated to fall within this dimension.

- To allow for the introduction of the ILI tool into a pipeline, the operator must provide a flanged access point with included valve isolation. The ILI tool will be inserted into spool piece that can be installed to the flanged access point. The umbilical (tether) is then fed through a customised stuffing box that includes multi-stage isolation with the ability to transfer any gas leakage in the first stage to a flare.

The efforts towards delivery of this solution are ongoing and considered iterative. The expectation is to have this 8 in. solution commercially available by the end of 2023.

Unpiggable pipelines will continue to push the boundaries of the technical capabilities for ILI tools. The illusive title of 'unpiggable' will continue to be a function of time as these boundaries are continuously crossed.