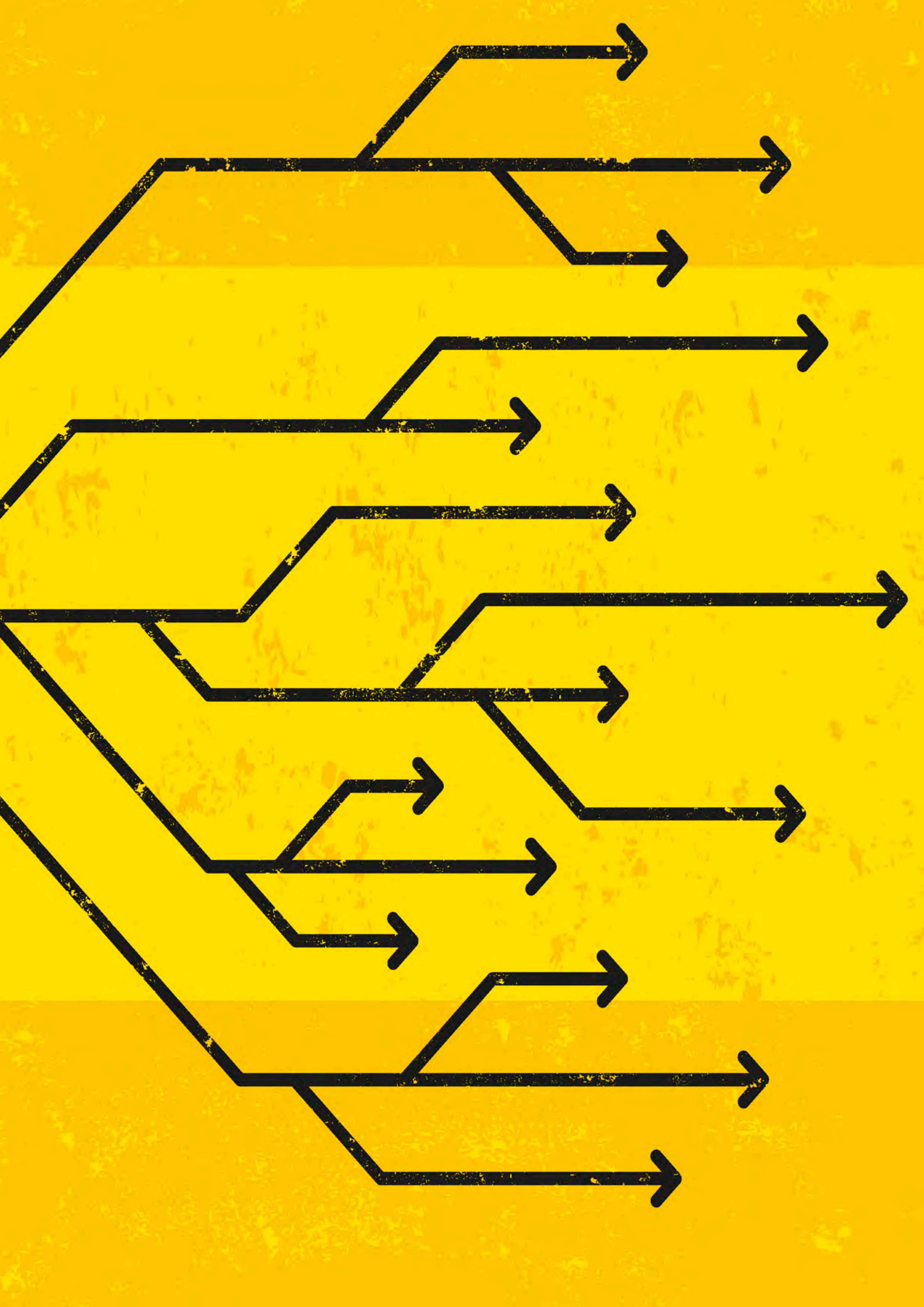
FINDING THE RIGHT ILI METHOD

Ron Maurier and Dan Revelle, Quest Integrity, USA, delve into the difficult task of determining the right inspection technology for unpiggable pipelines.

Modern inline inspection technology has been revolutionised in the past few decades, making the concept of 'unpiggable' pipelines a thing of the past. However, today's inspection challenges are no less complicated and are often more arduous than ever. With the rise of technological innovations come new complexities in determining the appropriate tool for each unique pipeline inspection. Operators are now faced with numerous reliable inspection technologies, often choosing inspection methods based on budgetary restriction or a limited understanding of what damage might be present within their pipeline.

The difficulty in determining an appropriate inspection technology is largely based on what an operator might not know about their pipeline. Factors including environmental constraints, pipeline product and pipeline configuration have a significant effect on the type of inspection technology that will appropriately detect damage to a line. The type of damage mechanisms seen within pipelines are also affected by these factors. Defects including specific types of corrosion, erosion and pitting can vary significantly based on the condition of the pipeline.



Damage mechanisms that cause integrity concerns

In most cases, unpiggable pipelines share the same damage mechanisms as piggable pipelines. The complication for unpiggable lines is generally that the pipeline is much more difficult to inspect, making pipeline defects harder to detect. The damage mechanisms found in pipelines vary in severity, but can be consistently seen throughout unpiggable lines worldwide. A number of pipeline defects, listed below, can be fairly easily mitigated, but can be difficult to properly detect and measure.

- Wall thickness and metal loss changes.
- Changes in geometry.
- Corrosion.
- Corrosion under insulation (CUI).
- Erosion.
- Pitting.
- Deformations including denting, gauging, ovality, bulging and swelling.

Difficult-to-detect defects in unpiggable pipelines

There are a number of circumstances for which a damage mechanism might be undetected or misread, depending on the tool methodology utilised during an inspection. Factors including pipeline configuration, product throughput and misinterpreted anomalies can have lasting effects on pipeline health, exposing operators to costly outages and potential safety risks.

Unusual pipeline configurations (Figure 1) can limit the inspection capability of some tool technologies, making tool selection a critical first step during an inspection process. Pipeline segments that have not been designed or modified to support inline inspection (ILI) often contain pipe tees, back-to-back bends, or short radius turns that create navigational and data quality collection challenges for many ILI tools. It is vitally important that an inspection tool is capable of maneuvering these challenging sections of pipe.

Maneuverability is not the only limiting factor to consider when inspecting lines with complicated navigational features. Data collection coverage at pipeline bends can also be a serious problem for specific tool form factors. Conventional inspection technologies are not always able to fully capture data at the tightest of pipeline bends, which can inevitably lead to undetected defects and potential failures in the pipeline. While some inspection providers are developing tools that are capable of navigating through these challenges, it is important to note that in order to facilitate navigation, sacrifices are sometimes made that can impact the data collection capabilities throughout the entire inspection. For example, the magnetisation section of a tool may be shortened so that 1.5D bends can be navigated. In order to verify tool capability in these complex configurations, it is critical to perform test runs that mirror any potential pipeline configuration, prior to inspection.

Unpiggable pipelines that might experience these issues require specialised detection capabilities. By understanding the configuration challenges for each individual pipeline prior to inspection, operators are able to alleviate many of the risks associated with potential data collection issues.

Corrosion damage in unpiggable pipelines

The most common, and often most deleterious, damage mechanism seen in pipelines is corrosion. The following types of corrosion occur in non-standard environments, and are now being seen with more frequency.

- Corrosion under pipe supports.
- CUI.
- External corrosion due to coating failure.
- CO_2 top side corrosion.
- External corrosion in high voltage utility corridors.

Figure 1. Examples of various complex piping configurations once deemed unpiggable.

- Riser and splash zone damage in offshore pipelines.
- Corrosion due to stagnant product flow.
- Damage caused by urban infrastructure and pipeline inaccessibility.

Ultrasonic inline inspection

Ultrasonic (UT) ILI, also commonly referred to as smart pigging or intelligent pigging, is an ILI technology that uses direct measurement of the pipe wall. Utilising up to hundreds of precise sensors, UT tools travel the interior of a pipeline, taking overlapping ultrasonic measurements of geometry and metal loss features. Recently, high resolution UT tools have entered the market, allowing for better detection and characterisation of corroded areas, including small diameter defects.

Rather than taking approximate measurements of pipeline defects, UT inspection tools gather absolute wall thickness readings, providing exact damage calculations, rather than estimations. Because of this, ultrasonics tend to be the most reliable inspection method for data collection.

UT tool technologies are also well suited for inspecting heavy wall pipelines. Unlike magnetic flux leakage (MFL) tools that struggle with thick wall piping, ultrasonics are able to measure exact metal loss thicknesses, regardless of heavy wall restrictions. Lines whose designs require thick wall piping, including offshore pipelines, largely benefit from UT tool technologies. Because UT inspection tools use ultrasound to measure wall thickness, they are directly measuring the pipe wall. For traditionally unpiggable pipelines where records and documentation can be lacking, a UT tool will provide for accurate characterisation of the as-built condition of the pipe as well as any and all anomalies that may be present.

Although UT ILIs are an extremely reliable method, there are a few limitations an operator must consider. In order to collect data effectively, an ultrasonic tool must be propelled in a couplant, therefore requiring liquid in the line at the time of inspection. Depending on the cost of running temporary fluid through the pipeline, it can be more cost-effective to use alternative inspection techniques for lines that do not generally contain liquid, such as gas pipelines.

Although any inspection methodology has benefits and limitations when inspecting unpiggable pipelines, the true test of capability is seen outside of theoretical situations. Real-world circumstances make unpiggable pipeline inspections considerably more complicated and must be assessed practically and on a case-by-case basis, in order to determine an inspection methodology capable of detecting any potential defects.

Time is key

In many instances, what may make a line unpiggable is the substantial amount of time it takes to inspect a complicated pipeline. For some operators, the prospect of taking a pipeline out of service for days at a time is not only impractical, but impossible. For example, if an operator cannot tolerate any reduced product flow, a number of inspection providers are automatically unable to perform an inspection. Depending on the operator's time restrictions, however, some inspection technologies are capable of inspecting 100% of an unpiggable line in under 24 hours without significantly modifying the line, allowing previously uninspectable pipelines to be inspected and returned to service in the same day.

There are two commonly recognised circumstances where time constraints have a particularly negative effect on inspection services. In some cases, an inspection must be completed quickly in order to place a line back into normal service in a short period of time. In other instances, an operator may have an extremely small window of opportunity to perform potential remediation, and requires immediate inspection results in order to effectively respond. Depending on the chosen inspection provider, these time constraints no longer deem a line unpiggable, as inspections and data reporting can be produced in a matter of hours, rather than weeks or months.

This capability is not, however, available from every inspection provider. The ability to both inspect and assess over the course of a few days (or less) requires a unique inspection and assessment methodology that is not always available. It is important to fully understand the delivery capabilities of inspection providers to ensure appropriate turnaround requirements are met.

Considering data resolution

Although modern inspection technologies have made profound strides in pipeline piggability, an inspection is essentially ineffective if the data collected during the inspection is of poor quality. Many of today's inspection technologies may sufficiently detect flaws, but may not be able to size the actual length, depth and severity of these anomalies. However, today's UT tool technologies are able to go beyond standard flaw detection, providing the highest quality data resolution and accuracy available in modern history.

High resolution data quality is critically important in order to better characterise anomalies, understand damage mechanisms and enable more accurate high level engineering assessments. One particularly significant benefit of acquiring high resolution data is the ability to plan for future maintenance. High resolution wall thickness data not only provides accurate flaw detection, but allows for Level 2 and Level 3 assessments on areas of metal loss, providing more accurate assessments of an asset's fitness-for-service. High quality geometry data also gives engineers the ability to calculate stress concentration factors or build finite element models of individual flaws in order to understand the actual threat of such anomalies. By gathering more high resolution data, an operator can better see how defects interact and what their true impact is to a pipeline's integrity.

If an ineffective inspection methodology is used, a number of problems can arise. If quality data is not collected during the inspection, it is possible that anomalies may be misinterpreted, or go completely undetected. Because navigational challenges are becoming less prohibitive, it is now critical that an inspection tool is capable of not only detecting flaws, but can also provide high resolution visibility to these areas of damage.

Budgetary implications of unpiggable pipeline inspections

It is generally understood that unpiggable pipelines can be extremely costly to inspect, maintain and repair. It can be argued, however, that the 'you get what you pay for' adage is accurate when it comes to ensuring pipeline integrity. The ability to successfully navigate a myriad of pipeline complexities, as well as collect excellent high quality data, allows for long-term performance and regulatory compliance that is well worth the upfront cost of inspection.

There are many factors that should be evaluated when determining an effective inspection technology. Because the operational requirements of inspection technologies can vary, it is important to examine the entire costs of an inspection project and view the entire solution holistically. Critical components of an inspection plan including navigational capability, site preparation, mechanical set-up and data quality are all important factors to consider. It is vitally important that tool technologies be scrutinised thoroughly in order to determine whether or not each individual pipeline criteria is met prior to inspection.

Another key difficulty for pipeline operators is justifying ILI on assets that have never been inspected. In today's unforgiving environment, pipeline inspections are more critical to perform than ever before, even for lines that have never failed or shown indications of damage. The phrase 'hope is not an integrity strategy' is a harsh but effective warning. Ultimately, the most crucial asset integrity decisions hinge on the ability to safely operate an asset, regardless of a pipeline's history. Accurate and repeatable inspections are truly the only effective method to ensure failures do not occur.

Conclusion

Increasing regulatory and public scrutiny of the energy industry is at an all-time high, making accurate pipeline inspections more critical than ever. By understanding the full scope of potential damage mechanisms, as well as the unusual factors that can make routine inspections extremely challenging, pipeline operators are able to confidently determine an appropriate inspection methodology based on each individual pipeline's requirements. Although ILIs are becoming more readily accessible, it is vital that all inspection methodologies be carefully considered along with the specific damage mechanisms expected in a particular line. By carefully weighing all of these factors together, operators can best extend the life of critical pipeline assets.

Bibliography

BEAVERS, J. A. and THOMPSON, N. G., 'External Corrosion of Oil and Gas Pipelines.' ASM Handbook, Volume 13C, Corrosion: Environments and Industries (05145). http://bit.ly/2oZ13Ra

DE LORENZO, R. 'Predicting the Future of ILI Tools.' World Pipelines (2017), pp. 25 - 29.

JAVAHERDASHTI, R., NWAOHA, C., and TAN, H.,'Corrosion and Materials in the Oil and Gas Industries.' 2016. http://bit.ly/2odfFRJ