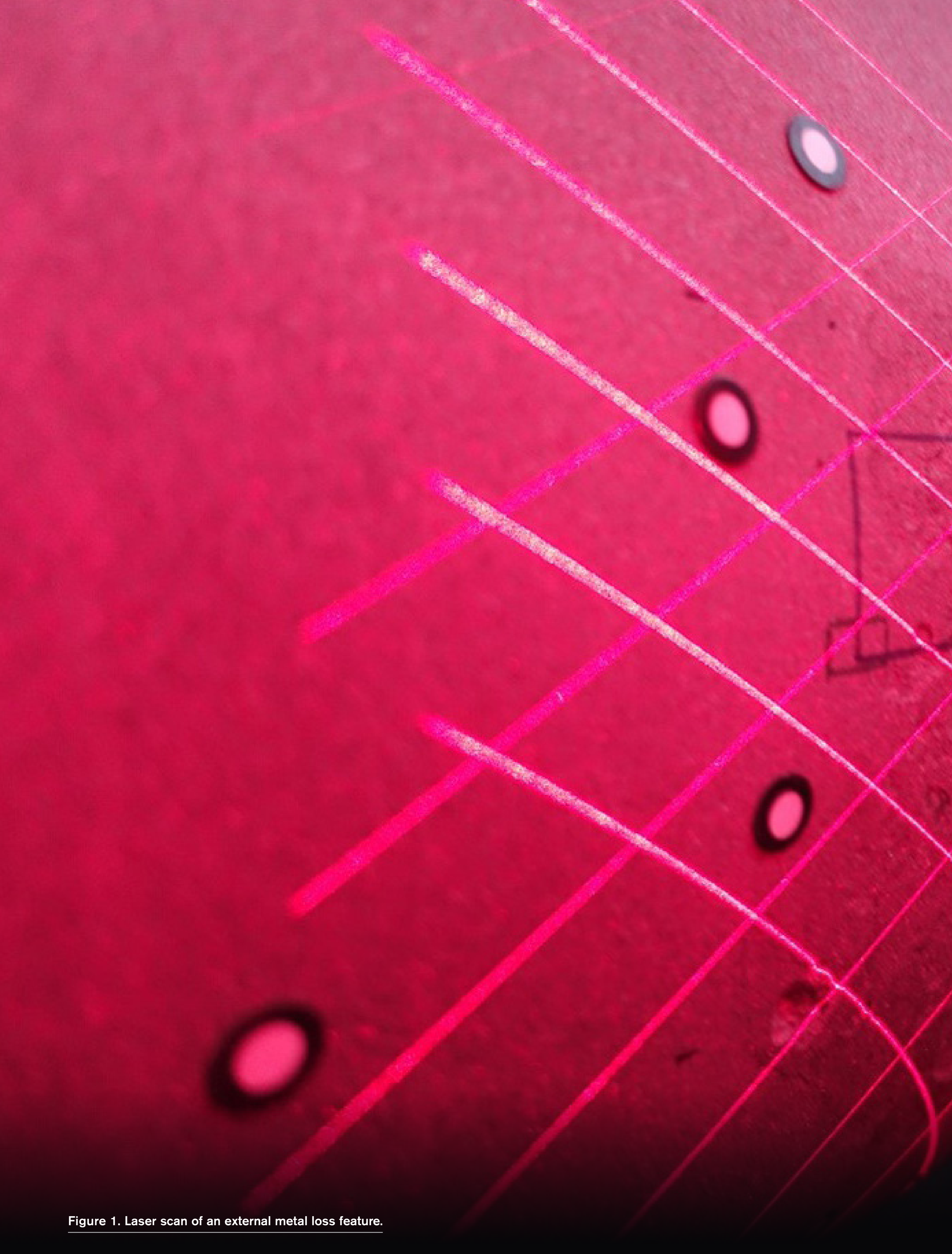
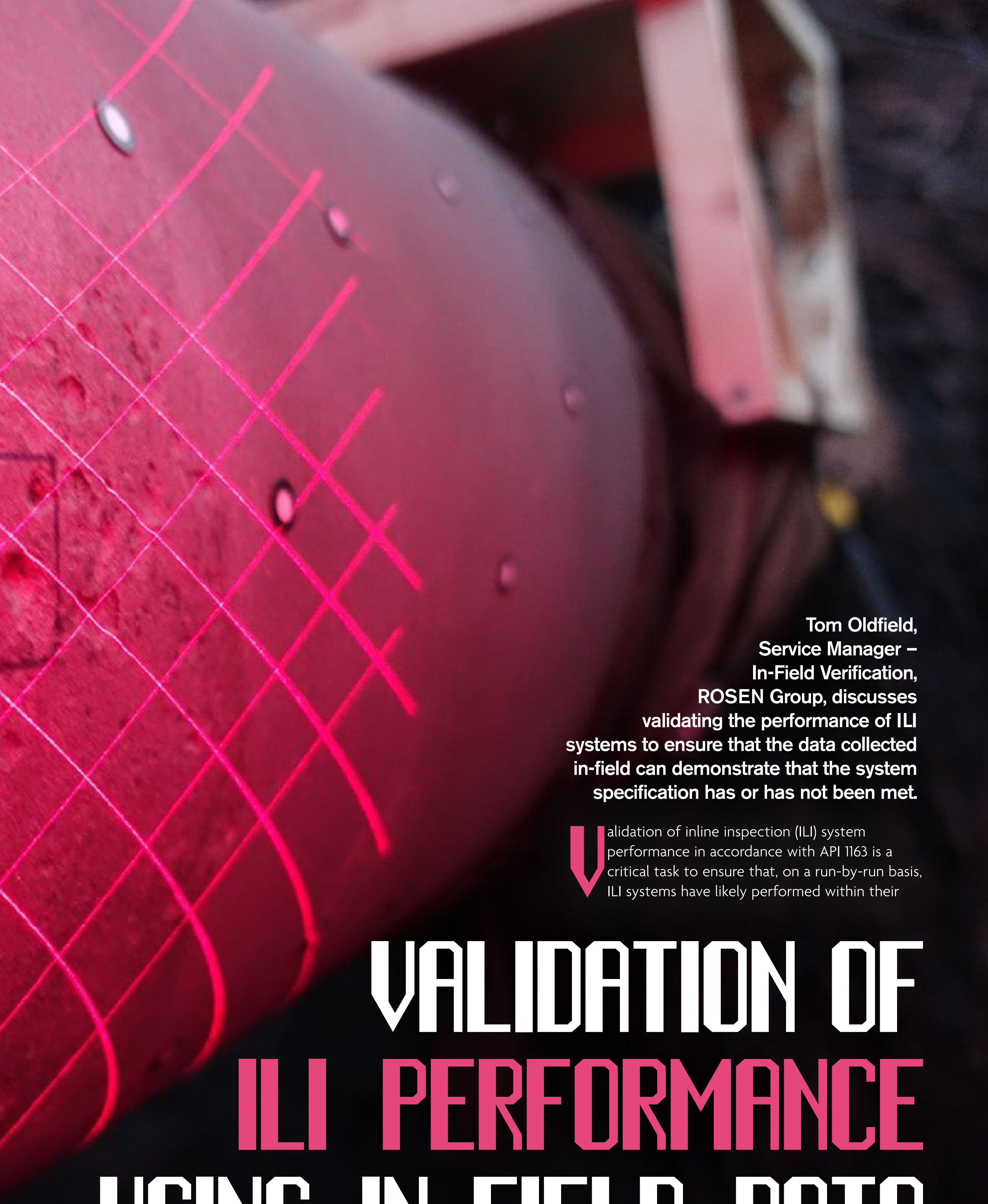


Figure 1. Laser scan of an external metal loss feature.



VALIDATION OF ILI PERFORMANCE USING IN-FIELD DATA

Tom Oldfield, Service Manager – In-Field Verification, ROSEN Group, discusses validating the performance of ILI systems to ensure that the data collected in-field can demonstrate that the system specification has or has not been met.

Validation of inline inspection (ILI) system performance in accordance with API 1163 is a critical task to ensure that, on a run-by-run basis, ILI systems have likely performed within their specifications (level 1 and 2) or can be used to understand case-specific, as-run performance (level 3) of an ILI system. Without understanding the system performance per run, it may not be conservative to use the stated ILI specification in subsequent integrity decision-making in case the ILI sizing falls outside the stated specification.

ILI systems are rigorously tested across a vast array of variables in the lab, in pull tests, and under real-world operational conditions to build up a basis of a specification. These specifications define the statistical probability of finding features of a certain dimension and classification to set a realistic expectation of the types of features that can be found and the certainty at which they can be sized.

To validate the performance of the ILI system, we need to ensure that the data collected in-field can demonstrate that the system specification has or has not been met. This typically goes beyond the data collection requirements needed for integrity decision-making, as the morphology of the features and the accuracy of the in-field inspection technique have a critical impact on the applicability of the ILI system specification.

Metal loss

External metal loss is the most common form of damage to cross-country pipelines worldwide, and the industry has a wealth of knowledge on both mechanical and semi-automated data capture with the likes of pit gauges and laser scanning. Laser scans provide high-accuracy, high-resolution data that enable signal-to-signal comparison of the ILI system vs in-field measurements. This signal-to-signal comparison is critical for a detailed understanding of system performance, as it can help to disseminate interacting features, breaking it down to the individual feature classification within clusters, which is fundamental to the physics driving the inspection quality.

A feature type typically mis-sized by ILI systems is the pinhole classification, which is less than 1 wall thickness (WT) in both circumferential and axial directions. This feature type is generally omitted from ILI specifications (except for the highest resolution systems) as features below this size reach the limits of the tool's sensitivity and capability to size accurately within its specification. If there is an area of significantly more aggressive localised corrosion within an area of general corrosion, understanding the dimensions of the pinhole within the cluster is critical in confirming that the system has or has not met the specification. Conventional methods of boxing the feature and identifying the peak depth with a pit gauge, while sufficient for conservative integrity assessments, do not paint a clear enough picture for ILI system validation.

Internal corrosion has the potential to provide highly detailed feature information when using a dual-axis encoded phased-array ultrasonic testing (PAUT) mapping system with an accuracy potentially an order of magnitude higher than an MFL system. When correctly processed, this data enables us to see the internal surface of a pipeline in operation with significant detail. However, this is a slower, more expensive technique requiring higher-skilled personnel to deliver the work. The general trend still leans towards manual UT, which, in theory, when applied by a competent person, can identify the deepest point and general area of corrosion and be applied to conservative integrity assessments, but again this does not provide sufficient detail to validate the ILI system performance. Encoded PAUT is the preferred method for ILI validation data capture due to the digital fingerprint of the feature that is created and can be interrogated.

A better understanding of ILI system behaviour within its specification not only enables a fair representation of ILI performance but also enables an integrity management strategy to cope with the specific needs of the pipeline in question, particularly when aggressive corrosion morphology is present.

Geometry

Geometric defects can be measured in field with the same level of accuracy as corrosion when using a laser system. However, there is the additional complexity of variations in pressures and elastic rebound from removal of the indenters. This is an area where validation of the absolute performance of the system is complex and there is currently no real agreed industry methodology for validation of these types of features.

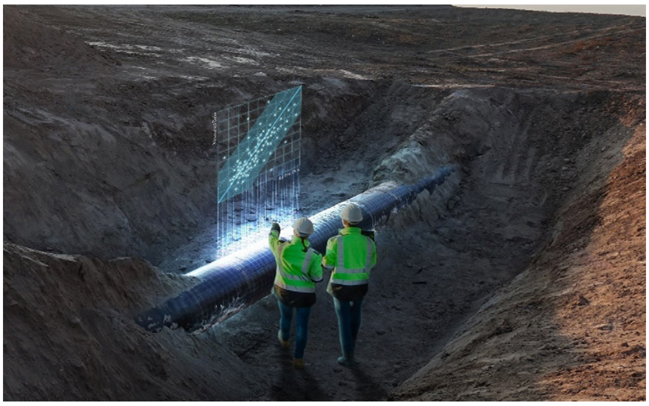


Figure 2. Comparison of ILI preface with in-field data.

Figure 3. PAUT inspection of a long seam.

Cracking

Cracking is perhaps the most complex form of defect found in pipelines from both an inspection and integrity management perspective.

Validating ILI system performance for cracking has two significant considerations: 1) How is the accuracy of the in-field measurement factored into the validation and 2) Does the in-field measurement demonstrate compliance of the ILI system to its specification?

The first factor is a complex one; determination of the accuracy of an in-field measurement is a significant challenge due to the human element still prevalent in a large number of the methods used for depth sizing crack-like anomalies. In conventional NDT, applying a large tolerance compensates for the measurement uncertainty, resulting in a conservative outcome. In ILI system validation, features are deemed to be acceptable if the measurement is within the combined tolerance of the ILI and in-field result, in the manner described in API 1163. Therefore, the greater the uncertainty in the in-field tolerance, the more likely it is that a feature will be accepted as meeting the specification, but in reality, creates a higher uncertainty in the performance of the ILI data set. However, assuming in-field data is absolute creates an unfair representation of ILI system performance. For this reason, technicians taking these measurements should be capable of achieving a high level of consistent accuracy, using the most transparent technologies to reduce the uncertainty in the ILI results.

The second factor mirrors the challenges seen in metal loss validations: is the captured data capable of determining whether or not the ILI system has met its specification?

It is possible for some in-field technologies to collect high-quality encoded data, which can provide sufficient evidence to support the ILI validation process. This is subject to the feature morphology being investigated, the particular setup of the in-field technology, and the experience of the operator in the purpose of ILI validation.

A good example of this can be from an issue reported by ILI on an ERW seam weld. The in-field solution is to use axially encoded high-resolution Total Focus Method (TFM) ultrasonic inspection data collected by a competent person with a known tolerance of 0.8 mm at 80% confidence from blind trials of the NDT system. With this system in place, various factors like the inclination to the pipe surface can be assessed to identify hook flaws, the intermittent nature of the features can be correctly quantified at the detection threshold, and the combined tolerance from API 1163 is small enough to have a high confidence in the resulting ILI depth sizing.

An example of poor data collection for ILI validation could be manual or spot PAUT measurements of unknown quality of an SCC colony to determine the deepest point, length and width (which again is acceptable from an integrity perspective), but ultimately does not provide sufficient evidence to demonstrate that the ILI system has met its specification.

This again is important as ILI systems have limitations for the minimum length of the feature, length of the peak depth, threshold length, how the subsurface inclination may affect the sizing ILI system, and it is important that these factors are considered when validating ILI system performance.

There are many available NDT technologies to size cracks in pipelines, but from a validation perspective, the use of a technique that can be interrogated to understand the morphology and size with a high level of accuracy is preferential. The Total Focus Method (TFM) Ultrasonic is one that shows potential to fill this criteria, but has operating limitations that mean it is not a silver bullet to solve all problems.

Field verification personnel

Hopefully, it is clear how important the role of the field verification technician is as part of this process. The data collected has to be of the highest quality, taken in what can be very challenging conditions. The data has to be traceable and reliable but also needs to demonstrate whether the feature meets the ILI specification or not. Once the raw data is processed and the report of the feature dimensions is written, the subtle complexity of how the feature really looks can be simplified to three numbers: length, width, and depth.

When the expectation of an ILI validation technician is compared to the role of a conventional NDT inspector, where only the peak depths, lengths, and widths are requested as part of an inspection report, it is clear that there is a potential gap in the knowledge expected from the people delivering this work.

API 1163

The practical application of API 1163 has recently been given a boost with the release of the supplementary guidance from PRCI (PR-719-223803-R01), which has provided more clarity on how to implement the standard. However, the fundamental collection of data and the understanding of the purpose of an ILI verification still lack the clear guidance required. Through better collaboration between ILI vendors, operators and their NDT contractors, a better understanding of the ILI validation task should lead to data that better represents ILI performance and the integrity threats to the pipeline.

Conclusion

Without high-quality in-field verification data, it is difficult to assess the performance of an ILI system. This can potentially lead to non-conservative integrity decisions if the ILI tool is not performing within its specification or if the morphology of the particular features is more severe than the tool is capable of seeing.

ILI verification is a challenging task, but there is a much better chance of a successful inspection with a clear understanding of what the data is being used for and the importance of quality within this process. With this knowledge, it is possible to create a clear work scope to allow NDT companies to develop procedures that are suitable for the purpose of ILI validation data collection and not only immediate integrity decision-making.

With a wealth of experience in in-field verification and ILI, ROSEN can help establish clear in-field work scopes to ensure the highest-quality data collected in the field is relevant to the verification task and maximises the value of the excavations on their pipeline networks.