PII Pipeline Solutions
a GE Oil & Gas and Al Shaheen joint venture

Getting to the bottom of pits & pinholes

PII's new super-high-resolution UltraScan™ WM+ ILI tool achieves customer validation

Challenge

Pipeline wall measurement with liquid-coupled, ultrasonic in-line inspection technology is well established after more than 25 years of industry use. However, where pitting and pinholes are concerned, reliable detection and accurate sizing were particularly challenging for these technologies until the limiting factors regarding sensor density, processing speed, and axial scan pitch could be overcome with recent PII innovations.

When assessing a defect's severity for integrity studies and fitness-for-purpose investigations, a key consideration is the accuracy of the reported dimensions — the probability of detection (POD), and the tool's sizing accuracy, which is stated as an accuracy level and a percent certainty. Magnetic flux leakage (MFL) and ultrasonic technology (UT) are well proven for the detection of metal loss and corrosion. Their typical depth sizing specifications are as follows:

- High-resolution MLF tools: ±12% wt with a 90% certainty level (mean error of 0% wt, standard deviation of 7.8% wt)
- Super-high-resolution MFL tools: ±10% wt with a 90% certainty level (mean error of 0% wt, standard deviation of 6.1% wt)
- High-resolution UT tools: ±0.5 mm with a 90% certainty level (mean error of 0 mm and a standard deviation of 0.3 mm)

We set out to build a new UT tool that would beat these specifications, and increase the visibility of pitting and pinhole corrosion sites.

Solution

Our objectives were to detect and size defects as small as 5 x 1 mm, and determine remaining wall thickness with significantly higher accuracy than standard technologies. The key to reaching these goals was to design a new sensor carrier that integrates more sensors than existing high-resolution technologies.

CHALLENGE

Small pitting and pinhole corrosion sites can have a significant impact on pipeline integrity and corrosion growth. They are, however, extremely difficult to identify and accurately size, even with modern high-resolution inspection tools.

SOLUTION

UltraScan WM+ is a new super-high-resolution ILI tool that delivers significantly higher axial, radial and circumferential resolutions to improve both the detection and sizing of pitting and pinhole corrosion.

BENEFITS

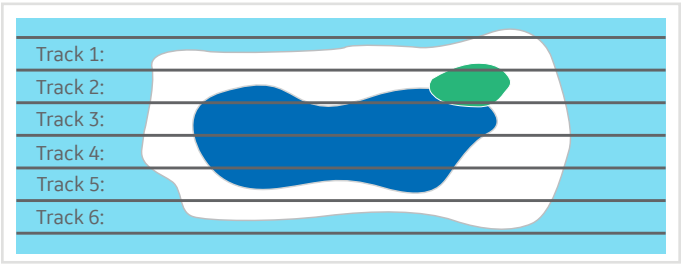
After fully documenting the performance of UltraScan WM+, and officially accepting its specifications, the customer awarded PII all its wall measurement inspection business for 2016 — using the new, validated super-hi-res tool.

Axial resolution has been increased by cutting the scan pitch in half, from 3 mm down to 1.5 mm — meaning that a 10 mm pit will now be hit by approximately 7 ultrasonic beams, versus 3 with the standard hi-res technology.

Circumferential resolution has been similarly increased by cutting the track distance in half, from 8 mm down to 4 mm, resulting in 7 ultrasonic beams per inch, versus 4 with the standard hi-res technology.

Those specs are for the UltraScan WM+ standard sampling grid — but tighter grids are feasible.

Radial resolution provides a 0.1 mm minimum wall thickness measurement accuracy, which identifies smaller defects than possible with standard high-resolution tools, and gives more measurement graduations. The 0.1 mm accuracy can be achieved independent of the wall thickness of the pipe.



In this simplified illustration, the deepest point of the feature is located in Track 2. A high-resolution tool would have widely spaced sensors in tracks 1, 3, and 5 — so the defect's deepest point would be missed. With WM+ super-high resolution, however, sensors are active in all 6 tracks, providing the much wider circumferential coverage needed to record more points and, therefore, more accurately measure the defect's depth.

The improved axial and circumferential resolutions combine to enable higher sizing accuracy, certainty, and speed (up to 3 m/s). The radial improvement provides more accurate river-bottom profiles of each defect.

Beyond improved sensor configuration, the new WM+ tool has an enhanced electronic core module with increased computing power to support the greater number of sensors and higher inspection speed. It also enables sophisticated online algorithms for signal processing, and can record the signals for further offline analysis, which potentially allows for post-run improvement of data quality. The tool can also be configured to record A-scans that, combined with an offline algorithm, can be used to analyze complex defect geometries and refine the inspection results.

The WM+ tool passed our rigorous set of testing and qualification programs with flying colors. But we needed to validate it in real, in-field operating conditions. One of our North American customers stepped up with a plan.

In-field validation

Their integrity team proposed that we run the new WM+ tool through a pipeline section for which they had a lot of historical data from both MFL and UT technologies.

UltraScan WM+ made its maiden voyage on June 23, 2015 through 175 km of a crude oil pipeline. Tool velocity was maintained well below the maximum nominal survey speed range. The run took 58 hours and the tool was received in good condition, with sensors and the entire sensor carrier free of wax and debris.

This section of pipeline had been inspected multiple times over the last five years, in all cases with our most advanced technologies — including phased array UltraScan DUO for crack detection, and MagneScan SHR for corrosion detection. So we had plenty of high-quality data for verification purposes.

Benefits

For initial validation, the customer focused on detection and characterization of pitting and pinhole corrosion, but all available feature data in the 33 km sample segment was used for the validation, regardless of morphology. To complete the validation, they used statistical analysis based on API 1163 and the Guidance Document on Metal Loss ILI Tool Validation produced by the Canadian Energy Pipeline Association (CEPA) [6, 7].

Field NDE results were collected following industry and customer standards and guidelines to maximize accuracy and minimize uncertainty. In addition to checking performance of the overall dataset, results were reviewed by sub-sectioning the data by feature morphology, depth range, and proximity to the weld.

A total of 185 matched ILI and field NDE measurements were available for analysis. According to API 1163, UltraScan WM+ performed better than its 90% certainty specification for sizing accuracy — exhibiting a $\dot{p}_{upper}$ value of 94.2%. The CEPA method also showed acceptable precision for deterministic and statistical probability of detection, with a minor bias towards under-calling. WM+ met or exceeded its stated 90–95% POD specification for the overall dataset of feature morphologies — with a $\dot{p}_{upper}$ value of 97% for pitting corrosion, 100% for pinholes, and the stated specification for extended corrosion.

		Super High Resolution UltraScan WM+ Specification		Validated by customer
Detection	Min. detectable defect (≥5 mm Ø x 1 mm)		90-95%	100%*
	Morphologies detection overall		90-95%	97%
Sizing	Sizing accuracy overall	±0.4 mm	90%	94.2%
	Pitting		90%	97%
	Pinholes		90%	100%
	* small sample size		Certainty	$\dot{p}_{upper}$

UltraScan WM+ has therefore been validated. It increases defect-sizing certainty, and reduces the corresponding errors associated with comparing repeat ILI runs, which in turn improves growth-rate determination. It allows for higher confidence in developing immediate and short-term repair schedules, while long-term remediation activities and re-inspection intervals can be substantially improved.

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