Seam Assessment and Regulatory Compliance: Multiple Datasets + EMAT

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INTEGRITY MANAGEMENT PLANS (IMP) are a growing need in the pipeline industry. Not only does an IMP prove to government regulatory bodies that the operator is taking the required safety precautions to protect the environment and personnel, but having a plan in place can also help mitigate costly future repairs and possible pipeline failure.

The right inspection tools are a vital part of any IMP. But as technology changes, an operator's existing IMP may become inappropriate for the amount and type of data provided by the newer tools. The need to update an IMP typically becomes clear after a pipeline inspection yields too much data to be handled by the required action items.

The following case study illustrates a scenario in which an operator must choose new inline inspection (ILI) technologies for future seam assessments and to create a new IMP. To do so, the operator runs four different ILI tools and compares the accuracy of the data. Although this specific scenario was put into action to comply with regulations set by the United States Pipeline and Hazardous Materials Safety Administration (PHMSA), the study's results — a comparison of ILI technologies — can benefit pipeline operators around the globe.

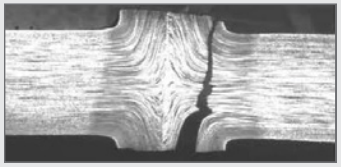
THE NEED

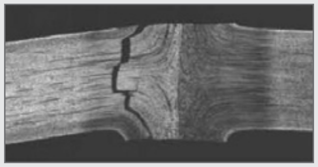
In early 2015, a U.S. liquid operator faced multiple ruptures due to hook cracks and lack of fusion in the long seam of its low-frequency electric resistance welded (ERW) pipe. After a segment of the pipeline leaked over 5,000 gallons of liquid propane, PHMSA forced a pressure reduction until the operator could prove that it could safely operate at Maximum Operating Pressure (MOP). That meant the operator had two options: Hydrostatically test its lines and make repairs, or run a seam assessment tool on the pipeline and repair the defects according to its current IMP.

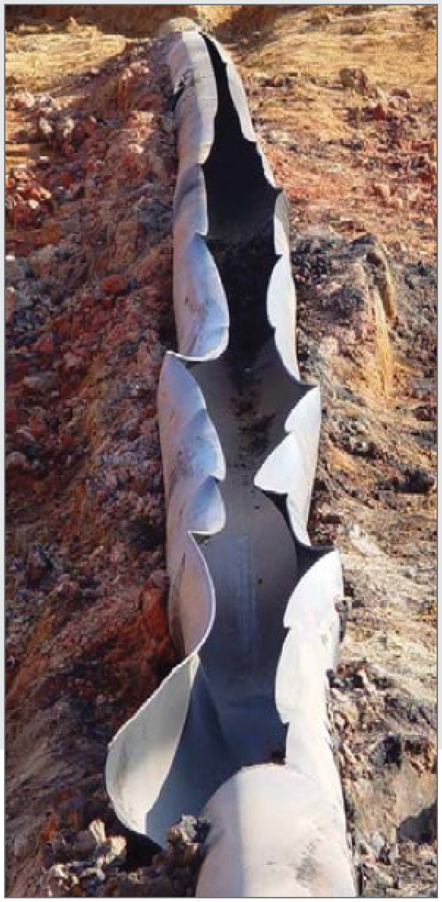
In addition to running a full seam assessment on the reduced-MOP pipeline, the operator needed to find an ILI tool or combination of technologies for future pipeline evaluations. To make this decision, the operator decided to run four different ILI technologies from multiple vendors. The goal was to find a comprehensive method for identifying seam defects on the pipeline and prioritizing repairs.

For the seam inspection, the operator chose ultrasonic crack detection (UTCD), circumferential magnetic flux leakage (CMFL), and a Multiple Dataset (MDS) tool along with an electromagnetic acoustic transducer (EMAT) tool.

Seam Defects and Pipeline Failures







The Goal: Find a comprehensive method for identifying seam defects on the pipeline and prioritizing repairs.

The action plan was to run all four ILI technologies, compile the data pulled from the pipeline by each tool, summarize the results, make the necessary repairs according to the existing IMP, and get approval from PHMSA to remove the pressure reduction. PHMSA's timeline for integrating these four ILI reports along with historical pipeline data and creating a repair plan was 180 days. If repairs were not made by the operator within that timeline, another pressure reduction would be required.

The action plan was to run four ILI tools, compile the data, summarize the results, and make the necessary repairs according to the existing IMP.

PROJECT CHALLENGES

The operator ran the four various inspection tools in the pipeline. The final reports revealed an enormous compilation of data detailing 605 crack, crack-like, and possible crack-like features on a single pipeline:

- » SpirALL® EMAT reported 302 cracks in the seam.
- » UTCD reported 74 cracks in the seam.
- » MDS with SpirALL Magnetic Flux Leakage (SMFL) reported 55 crack-like axial planar features in the seam.
- » CMFL reported 24 crack-like features and 150 possible crack-like features.

To complicate matters, the operator's current IMP required a response to each and every crack, crack-like, and possible crack-like seam feature reported by the tools. That meant the operator had to schedule dig plans for all 605 defects in order to verify that they needed repair. This method would be a costly, time-consuming plan, and with the data provided by the advanced ILI technology, this original IMP might not be necessary to prevent pipeline failure.

The new IMP would have to be validated internally and then approved by PHMSA, and in the meantime, the operator needed to develop plans to repair all 605 crack, crack-like, and possible crack-like features found during inspection to comply with the current PHMSA-approved IMP. If the operator moved quickly, it could begin scheduling digs and get its new IMP approved for the remaining defects.

In order to recommend an ILI technology to include in the new IMP and for future seam assessments, the operator needed to take the huge amount of data provided by the four different tools and decide which one provided the most useful data for their future needs (see chart to right).

THE OPERATOR CAME UP WITH TWO ACTION PLANS:

1) Prioritize the seam defects by length, depth, and location and then begin executing repairs.

2) Develop a new IMP that would allow them to better manage the large amount of data found by the ILI technology without being forced to dig for every defect reported. It would require repair plans for only the critical defects and monitoring for the other defects, followed by a re-inspection plan to track growth of unrepaired crack-like features.

Operator's ILI Data Source Options

1. Opt for the older UTCD technology, which is a proven industry standard, but missed several significant defects during inspection.

2. Run the newer SpirALL EMAT technology, which was gaining industry popularity because the technology finds more defects of significant depth and length.

3. Use CMFL to find crack-like features, possible crack-like features, or seam weld anomalies. However, this technology categorized some defects as possible crack-like features, which turned out to be anomalies such as a misaligned seam or lack of trim, but not crack-like. Miscategorizing can lead to unnecessary digs and can prove extremely costly when there are 150 possible crack-like features reported.

4. Rely on combined MFL-based technology with MDS, which used MFL and SMFL. This method gives two different field angles to differentiate crack-like (e.g., axial planar) from possible crack-like defects. This would help reduce a large number of unnecessary digs.

5. Perform hydrostatic testing, an alternative to ILI which identifies critical defects that fail above a specified pressure, with a disadvantage in that the method will not find defects below a certain length and depth, which could become critical in the near future.

SOLUTION

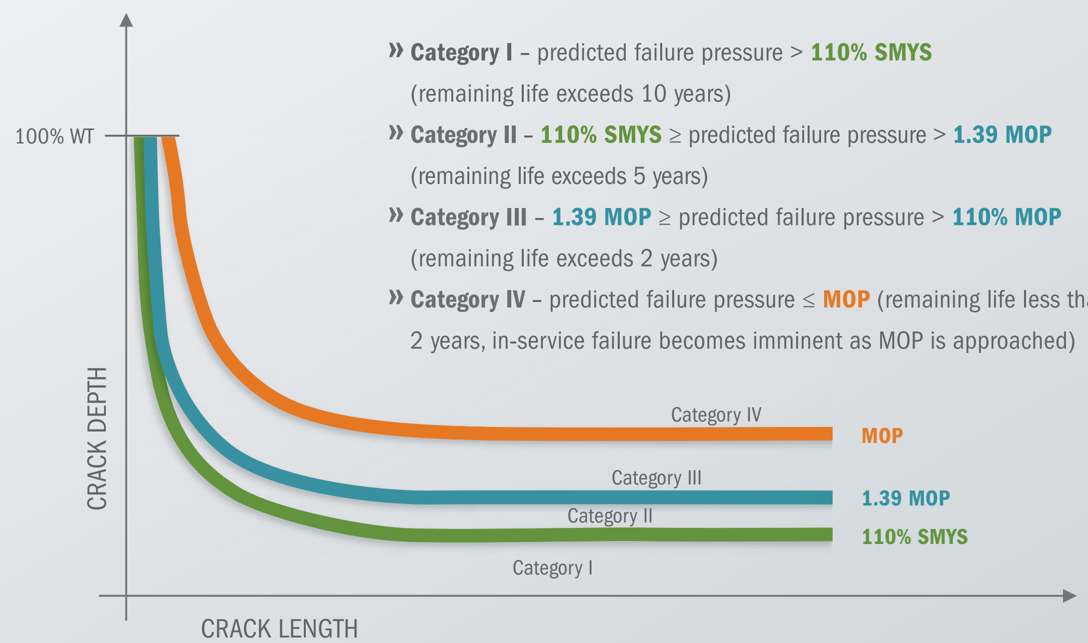
The operator was able to eliminate one of the options almost immediately. Hydrostatic testing was not chosen because the pipeline had so many critical defects that using hydrostatic testing on even a small segment could yield so many leaks that it would be difficult to determine where exactly they were in the pipeline, and the operator might have to excavate the entire segment to evaluate further. For that reason, ILI was more cost-effective for this particular scenario.

In the new IMP, the operator recommended combining ... both EMAT and MDS technologies as the best method going forward.

As for the remaining four options, the operator concluded that MFL-based technologies such as SMFL and CMFL have a limited width requirement (i.e. detection requires an "air gap" width to allow magnetic flux leakage to occur and be detected) in the defects that they find, meaning the narrower seam defects might be missed. UTCD, while an accepted industry standard, missed too many major defects to be deemed the optimal technology. By combining MDS with the bulk guided acoustic wave of SpirALL EMAT, the inspection detected lack of fusion and hook cracks in addition to correctly classifying the highest number of defects as cracks, crack-like features, and other seam weld anomalies. In the new IMP, the operator recommended combining technologies from options 2 and 4 above and using both EMAT and MDS technologies as the optimal method going forward.

To validate the results, the operator excavated the area around a percentage of the defects found through the combination of EMAT and MDS, and used non-destructive evaluation (NDE) to measure the defect and compare it to the ILI results. For example, if the ILI tools report a crack is 20 percent deep and two inches long, the result can be verified by digging up the area and measuring the defect externally with phased array ultrasonic (PAUT) technology, providing accuracy equal to or even greater than ILI.

Once the ILI results were validated through NDE, the operator was able to use the data to prioritize repairs. The analysis showed that the pipeline could continue to operate at MOP for another 10 years before the remaining cracks would cause critical failure. Using American Society of Mechanical Engineers (ASME) B31.8S and the Modified Log-Sec model to predict failure pressure, the operator analyzed and categorized the remaining crack and crack-like anomalies in the pipeline. These categories are shown in the graph below.



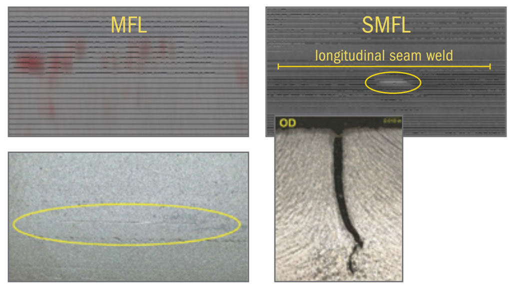
- **Category I** – predicted failure pressure > **110% SMYS** (remaining life exceeds 10 years)
- **Category II** – **110% SMYS** ≥ predicted failure pressure > **1.39 MOP** (remaining life exceeds 5 years)
- **Category III** – **1.39 MOP** ≥ predicted failure pressure > **110% MOP** (remaining life exceeds 2 years)
- **Category IV** – predicted failure pressure ≤ **MOP** (remaining life less than 2 years, in-service failure becomes imminent as MOP is approached)

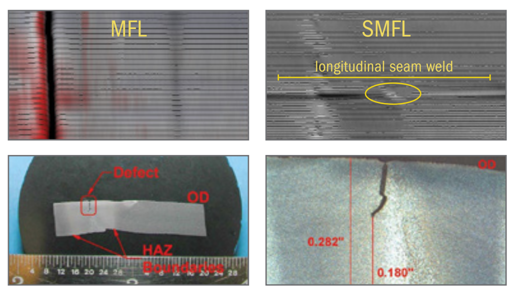
The operator concluded that all cracks and crack-like anomalies not repaired in the pipeline were reported in the Category 1 region (i.e., would be graphed below the green line).

The new IMP showed that using a combination of EMAT and MDS for seam assessments facilitated effective management of the crack and crack-like features of the pipeline. PHMSA did not take exception to the new plan, which meant that the operator did not have to complete the costly 605 digs in their original IMP. Plus, the company was now allowed to begin operating their pipeline at MOP once again, allowing more throughput of product and greater revenue.

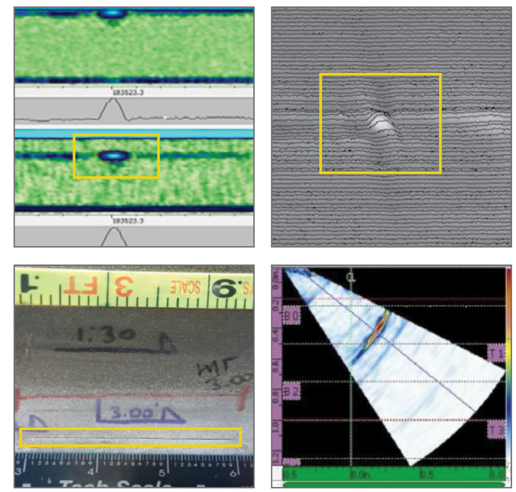
With their new IMP in place, the operator has made plans for inspections on seven additional pipelines with possible seam integrity issues. The combination of MDS and EMAT will be used for each future inspection.

Below are two examples of hook cracks identified by the Multiple Dataset (MDS) Platform. The SMFL technology aboard the MDS platform was able to clearly identify the hook crack in the long seam.

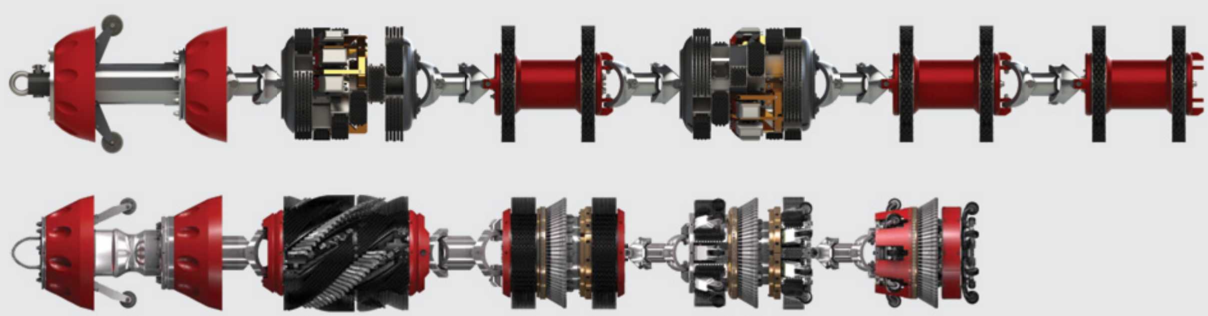




Top left: EMAT data reveals the location of a hook crack. Top right: SMFL data identifies the same hook crack. Bottom: Phased array NDE technology verifies the hook crack.



Using a combination of EMAT and MDS for seam assessments facilitated effective management of the crack and crack-like features of the pipeline.



MDS + EMAT technology enabled the operator to create a new PHMSA approved IMP that prioritized defect repair, allowing the operator to return to MOP.

Operator Benefits / Project Highlights

1. A liquid pipeline operator used four varied ILI technologies to detect and size crack and crack-like defects. The comprehensive SpirAll EMAT technology found previously undiscovered defects.

2. SMFL found many of the larger hook crack defects (also found by EMAT). This validation gave the operator confidence to dig to address these anomalies.

3. SMFL distinguished between features that would normally have been identified as seam feature B by CMFL.

4. The operator used the results to prioritize the list of crack and crack-like defects and make repair plans accordingly.

5. PHMSA approved the new IMP, allowing the operator to return to MOP.

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