



ADVANCES IN MAGNETIC PIPELINE INSPECTION

**Chuck Harris,
T.D. Williamson, Inc., USA,
explains how advances
in spiral technology are
providing superior defect
sizing and classification.**

Today's pipeline owners and operators are under intensive fiscal and regulatory pressure to ensure that their lines operate safely and efficiently. As a result, the need for accurate, reliable pipeline assessment is greater than ever. Through effective integrity management programmes (IMP), operators continue to discover and mitigate new integrity threats to their systems, and differing technologies must be run in order to locate those various threats. And, as more pipelines are constructed, made piggable and other existing lines

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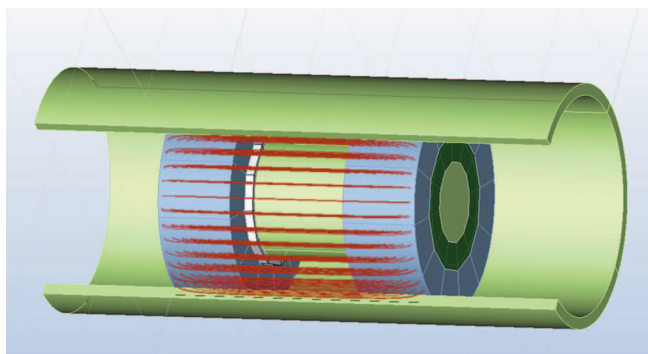


Figure 1. Traditional MFL inducing magnetism in the axial or longitudinal direction.

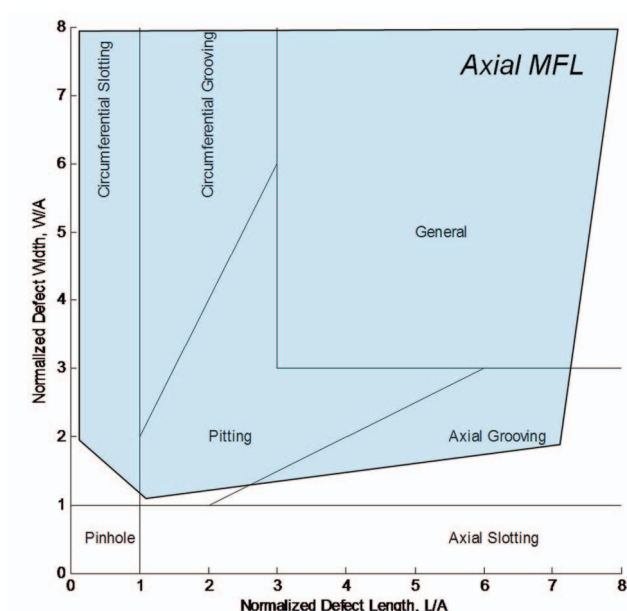


Figure 2. Graphical presentation of axial MFL limitations based on the POF. Geometries inside the blue-shaded area represent successful detection.

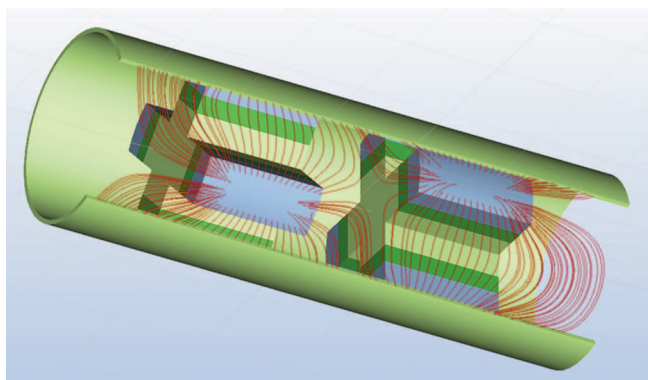


Figure 3. CMFL inducing magnetism around circumference. Second magnetiser required to achieve 100% coverage.

are integrated into IMPs, the ability to inspect them as resourcefully as possible is critical. The days when an inline inspection (ILI) tool was able to yield just one set of data per run are a thing of the past. Throughout the last decade, deformation and magnetic flux leakage (MFL) tools run in tandem became the standard means of providing operational efficiency to both pipeline operator and ILI service provider. This article will describe how T.D. Williamson, Inc. (TDW) has advanced the multiple dataset concept to a complete platform for comprehensive assessment of pipelines.

Enhanced accuracy

Depending on the type of threat, a number of inspection technologies are beneficial for assessing pipeline integrity. One such method is the MFL principle, which relies upon magnets to saturate the pipe wall in the axial direction while sensors oriented in the field detect 'leakage' that indicates metal loss. Refer to Figure 1 to review a model depicting application of this principle. The results generated by using the MFL method have made it the industry's most widely used ILI technology for metal loss and detection of other types of volumetric anomalies. As noted in 'Types of ILI tools and inspection purposes' in NACE SP0102-2010, however, all ILI technologies have limitations. MFL technology is no exception. Because magnetism is introduced into the pipeline longitudinally, abnormalities (such as those in the seam-weld) running in parallel with the magnetic field may not be detected. Figure 2 provides a graphical review of MFL limitations based on the pipeline operator forum (POF) specifications and requirements for intelligent pig inspection of pipelines. Wide features such as pitting and general corrosion, and circumferential slotting and grooving are easily detected. There are, however, limitations when it comes to detecting axial slotting and some grooving geometries.

Understanding the limitations of traditional MFL, the ILI industry saw an opportunity to create a solution for detecting longitudinally oriented anomalies. The answer was to alter the MFL technique to develop what has become known as circumferential magnetic flux leakage (CMFL). By inducing magnetism circumferentially rather than axially, the CMFL tool provided a solution to the limitations posed by traditional MFL. Magnetism bisects the axial plane, thus creating leakage in the magnetic field and allowing for the detection of longitudinally oriented anomalies. This approach does, however, require a second offset magnetiser due to the blind areas created by induction of magnetism 90° to the pipe wall. Figure 3 offers a representation of this technology application; notice the lack of coverage where the magnets are located, thus requiring the trailing magnetiser. Although CMFL detects crack-like features in long seams, other characteristics in the seam may be misrepresented, giving rise to concerns about data accuracy. Referring again to NACE SP0102-2010, CMFL, while useful for seam assessments, has its own constraints. Figure 4

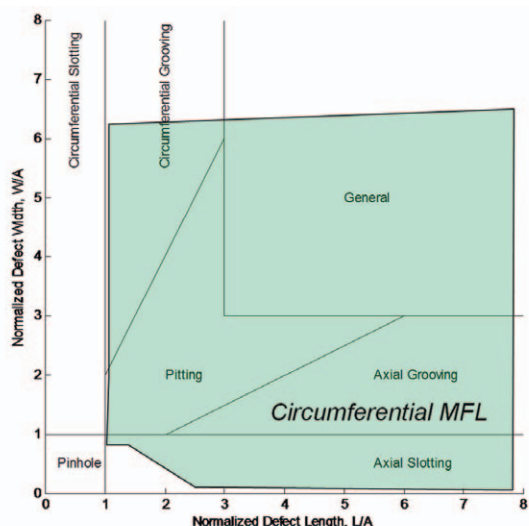


Figure 4. Graphical review of CMFL limitations based on the POF. Geometries inside the green-shaded area represent successful detection.

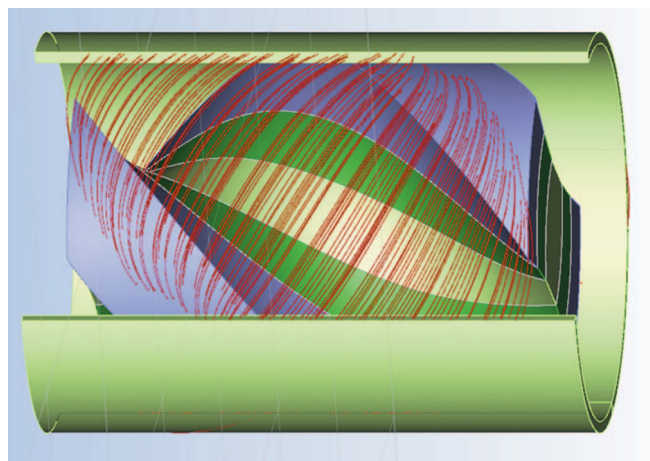


Figure 5. Spiral MFL magnetiser depicting complete coverage of the pipe wall for inspection of the longitudinal axis with a single magnetiser.

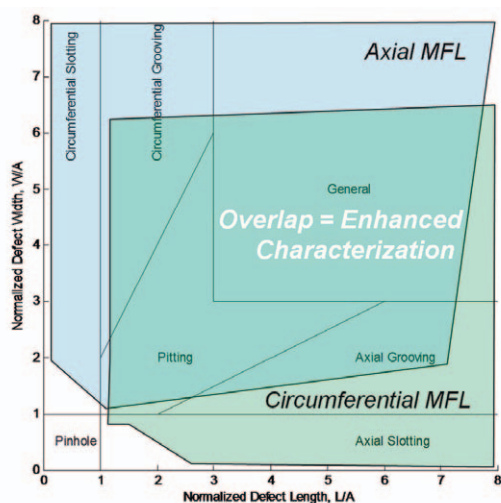


Figure 6. Graphical presentation of detection and characterisation advantages of MFL+SMFL based on the POF.

offers a graphical review of CMFL limitations based on the POF. In this case, there are gaps in circumferential slotting and other volumetric features that MFL does an excellent job of locating, while detection of axial slotting and grooving anomalies becomes possible.

While pipeline owners and operators utilise ILI technologies to ensure the integrity of their pipeline systems, running multiple tools can be time-consuming and can have a significant impact on operations. With advances in electronics, storage media, and inspection technologies, it is now feasible to gather numerous sets of data in a single inspection. Merging multiple technologies overcomes the limitations present when using separate tools and minimises operational impacts. TDW has developed a new approach to inspecting the longitudinal axis of the pipe. It relies on a spiral - or oblique - magnetic field in what is known as spiral magnetic flux leakage (SMFL). Figure 5 illustrates the SMFL magnetiser. Magnetism is induced at a 45° angle, which bisects the axial plane. The SMFL tool delivers the same full-wall coverage as the CMFL. The advantage is in the single compact magnetiser, which can easily be combined with other technologies, such as MFL and deformation, to eliminate the inherent limitations as described in NACE SP0102-2010 when using separate technologies.

Multiple datasets produced in one run = greater efficiency

SMFL is a much more compact design than other longitudinal axis assessment options, so it is easily combined with high-resolution MFL technology to overcome the limitations of CMFL. Figure 6 offers a graphical presentation of detection and characterisation advantages of MFL+SMFL based on the POF. The benefits of this multiple dataset approach are the ability to a) overcome the gaps created by each independent technology and b) use the overlap to provide enhanced characterisation and identification of anomalies detected by all datasets. By incorporating various inspection technologies onto one tool, many types of data can be collected in a single run, making reported results significantly more accurate. To illustrate, pairing SMFL and MFL allows for traditional external and internal metal loss assessment, quantification of longitudinal defects in the pipe body and accurate classification of seam-weld anomalies.

In addition, the MFL+SMFL platform is run in conjunction with other technologies, including high resolution deformation (DEF) for locating, sizing and determining orientation of diameter reductions or expansions. Plus, proximity (IDOD) sensors are installed on deformation arms in order to determine internal or external metal loss classifications and internal surface details. Low-field or residual sensors are also employed to detect hard spots, the 'halo-effect' created by dent re-rounding, and other flaws. Figure 7 depicts the multiple dataset tool

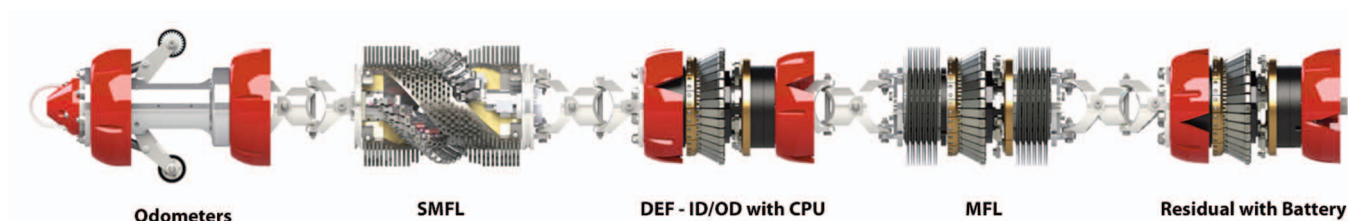


Figure 7. SMFL+DEF+IDOD+MFL+RES multi-dataset tool.

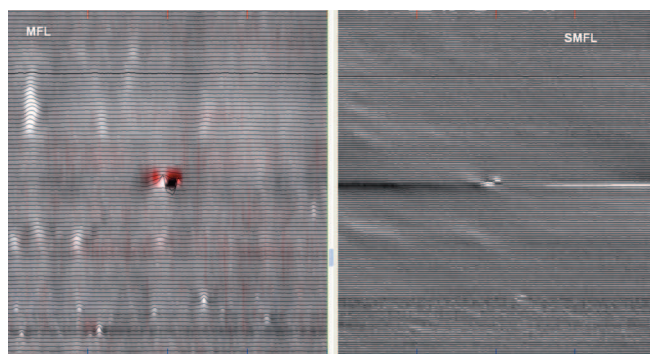


Figure 8. Example of seam anomaly confirmed via MFL not to be planar or crack-like. SMFL data reveals anomaly in the ERW seam. MFL shows an indication in the same position with mill anomaly characteristics. CMFL would report as crack-like or possible crack-like.

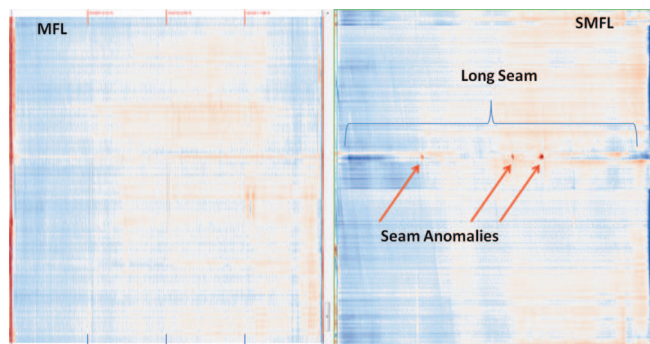


Figure 9a. SMFL data on the right reveals three distinct seam weld anomalies. Upon review of MFL data from the same run these anomalies are confirmed to be planar; no indications exist in MFL.

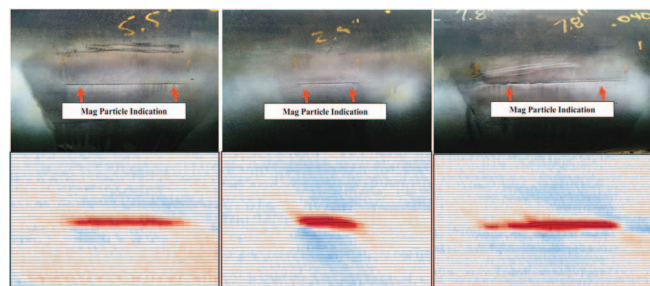


Figure 9b. The planar or crack-like anomalies correctly reported through use of multiple dataset technology and confirmed by field verifications. Magnetic particle was required for visual inspection. NDE results are included in Table 1 (anomalies 1, 2 and 3 are pictured here from left to right). Reported versus field results were highly accurate and well within the stated tolerances of the technology.

platform: SMFL+DEF+IDOD+MFL+RES. There is no 'wasted space', as all canisters include some form of measurement system. The drive section contains odometer wheels, second is the SMFL magnetiser, the third section contains deformation measurement (DEF) and IDOD sensors, fourth is the MFL magnetiser, followed by the residual unit (RES).

Inspecting a pipeline with a number of technologies achieves two things. First, it improves detection by providing more opportunities for a defect or anomaly to be discovered. Second, after an anomaly has been detected, use of multiple technologies makes characterisation more accurate. Armed with multiple views of an anomaly gleaned from a single inspection run, analysts have a more comprehensive view of a pipeline than ever before. The result? Pipeline operators receive superior results included in one final report, which provides enhanced anomaly characterisation and eliminates unnecessary excavations.

Inspection results confirm benefits

Results of recent inspections conducted by TDW confirm the benefits of using MFL+SMFL technology; overcoming the limitations present when running separate technologies, and using overlap to provide enhanced characterisation and identification of anomalies. Figure 8 offers an example of an anomaly detected in the long seam that is not crack-like or planar. The SMFL data clearly reveals a metal loss feature in the seam-weld. Upon reviewing the MFL data from the same inspection an indication is also present in the exact position. In fact, the signature in MFL is more typical of a mill-related anomaly than metal loss. According to technology limitations, any feature detected by MFL must have significant width, and therefore the case presented here confirms that this anomaly cannot be crack-like or possible crack-like. Had only CMFL technology been used to assess this pipeline, this feature would have been reported as crack-like or possible crack-like in the long seam. As such, the pipeline operator would have been required to excavate, only to discover that the feature was, in fact, not a planar anomaly.

In Figures 9a and 9b, three distinct anomalies located in the electric resistance welded (ERW) seam are apparent. Upon examination of SMFL data, the analyst noted three seam-weld features in the same pipe joint. During analyst review of the MFL data, it was confirmed that no corresponding indications exist. As such, these

Table 1. NDE results

Anomaly no.	WT (in.)	As reported			As found		
		Depth (% wall)	Length (in.)	Width (in.)	Depth (% wall)	Length (in.)	Width (in.)
1	0.250	19	4.3	0.05	16	5.5	(Linear)
2	0.250	29	2.4	0.07	14	2.9	(Linear)
3	0.250	15	7.4	0.08	16	7.8	(Linear)

features have no significant width, which means they are reported as planar or crack-like. Excavations validated the reported findings. Each location was identified in the seam within the joint via non destructive evaluation (NDE). Visual inspection of these indications could only be done through use of magnetic particle testing (MT). Reported versus field results provided in Table 1 reveal that they were highly accurate and well within the stated tolerances of the technology. Through use of multiple MFL techniques, guesswork is eliminated in anomaly classification.

Evolving technology

From the outset, TDW's objective was to create an alternative system for seam-weld inspections utilising a single magnetiser with the specific purpose of combining multiple technologies and multi datasets to achieve superior results over CMFL. "Our SMFL+MFL+DEF+RES multi dataset inspection systems have exceeded our expectations in terms of defect characterisation and sizing accuracies," said Scott Dauzat, Manager of Market Development for TDW's Pipeline Integrity Solutions. "The excavation feedback has definitely proven our concept for seam-weld inspections. Additional benefits are still evolving, such as dent prioritisation and dent strain analysis utilising our residual field sensors and high resolution deformation sensors. When a single inspection can provide sizing and characterisation for any defect

visible to MFL or SMFL, as well as locating mechanical damage regardless of dent size or depth, the benefits to our customers are readily apparent," he added. TDW clients have realised tremendous savings by eliminating unnecessary excavations because data analysts can confidently distinguish defect orientation (axial or circumferential), location, sizing, geometry, and volumetric vs. planar (corrosion vs. crack-like), among others.

Looking ahead

To date, SMFL technology, which is always run in tandem with MFL and other technologies, has been utilised to successfully inspect more than 1300 miles of pipeline. The ability to fully characterise an anomaly – whether hard spots, metal loss, axial gouging, narrow axial corrosion, seam defects or other longitudinal anomalies – using the multiple dataset platform increases inspection accuracy, efficiency and eliminates unnecessary, costly excavations. For pipeline owners and operators around the world, the benefits in terms of maintaining pipeline integrity efficiently and effectively are far-reaching. In addition to mileage inspected to date, there are more than 1000 miles of multiple dataset/SMFL inspection projects scheduled to take place during the next two quarters, an indication that the pipeline industry has been quick to embrace this valuable technology. **WP**