Inspecting the un-inspectable

David Russell, Ad Shatat and Yuwu Yu, Russell NDE Systems Inc., Canada, demonstrate the benefits of using an RFT ILI tool for sour gas pipeline assessment.

The remote field testing (RFT) technique has gained recognition as a unique NDE (non-destructive evaluation) technique for pipeline inspection since the 1990s.[1,2] Its application at that time was focused primarily on ferromagnetic waterlines, such as cast iron and ductile iron pipelines. RFT data collected for these pipelines reveals defects, such as graphitisation (a form of corrosion pitting that occurs in cast iron) and cracked cast iron pipes due to ground movement when season changes. RFT can also be used to inspect carbon steel pipes, such as cooling water lines in nuclear power plants and fire water pipes found in most large plants. Defects commonly found in carbon steel pipes include pits, wrinkles and dents, which can be detected by RFT-based technique.

Oil and gas pipelines, consisting of carbon steel pipes, have traditionally been inline-inspected by magnetic flux leakage (MFL) techniques for the past half century. MFL is a practical NDE technique so long as the pipelines meet certain conditions: no internal lining, no internal scale, no wax, no low flow conditions, no elbows and no multiple pipe diameters in one length of pipeline. The MFL technique requires close proximity between the sensors and the pipe wall and a speed between 5 and 15 km/hr. Internal liners prevent sensors from contacting the pipe internal surface and low flow does not allow ideal speed for the MFL tools to travel through the pipe. However, none of these factors prevent RFT technique from functioning properly since RFT technique intrinsically allows large clearance between sensors and pipe internal surface. Consequently, RFT-based inline inspection (ILI) tools can be employed in these challenging situations and can inspect oil and gas pipelines that MFL and ultrasonic testing (UT) cannot.[3-5]

As a case study in this article, there will be a discussion on the suitability of RFT ILI tools for assessing the condition of sour gas pipelines with thick internal liners, which present an insurmountable challenge to the other ILI techniques mentioned. It is both time- and cost-prohibitive for lining removal and subsequent re-lining in order to allow other ILI techniques to be used. RFT is the best candidate for thickly lined pipes in terms of its tolerance with large sensor liftoff created by the liner.

Sour gas pipeline condition assessment

Sour gas pipelines in Alberta, Canada, usually consist of carbon steel pipes with thick internal high density polyethylene (HDPE) lining. The thickness of non-structural HDPE varies and depends on several factors, including corrosiveness of the sour gas, pipe diameter and operating pressure. A cross-section of an 8 in. sour gas pipe is shown in Figure 1. The liner thickness is about ¾ in. HDPE lining is intended to prevent corrosive agents in sour gas from entering annulus between pipe internal surface and liner. However, methanol used for hydrate control and de-icing can permeate through the liner and enter the annulus. In the presence of moisture conditions, methanol becomes corrosive and can result in corrosion of the pipe internal surface, leading to pipeline failure.[6] Even though cathodic protection is applied to the pipe, external corrosion may also occur. It is thus paramount for sour gas line owners to inspect HDPE-lined sour gas pipes.

Figure 1. Cross-section of an 8 in. sour gas pipe.

Figure 2. A typical RFT ILI tool.

A typical RFT ILI tool is shown in Figure 2. The tool is flexible and can go around bends. Centralising loops keep the ILI tool properly centred inside the lined pipe and prevent damage to the liner. Exciter coils, sensors and electronics are sealed and encased in various modules of the tool. Working on the physical principle of double through wall transmission[5-6], the RFT technique is characterised by its many advantages to other NDE techniques such as: equal sensitivity to ID and OD defects; relatively insensitivity to tool wobbling; tolerance of large clearance between pipe internal surface and sensors, allowing inspection through thick liner and ability to continue taking readings at very low speed (and even when stationary).

An exhumed 6 in. sour gas pipe had two deep internal pitting areas and one long axial internal groove (narrow axial corrosion strip showing as long groove). RFT signal for these defects are shown as 3D plot in Figure 3. Also shown in Figure 3 are colour maps from automated UT (AUT) scan and through transmission (TT) scan as a comparison.[7] The internal RFT inline inspection tool successfully detected the two local pitted areas through the ¾ in. HDPE liner (the long groove was also detected but not shown in this colour map view). The AUT and TT scans were carried out after the pipe was excavated and cut from the pipeline; however, these scans show that the RFT inline tool was very effective at detecting and sizing the local corrosion area. It should be noted that the AUT scan required the removal of the external jacket and coating prior to the scan.

RFT ILI tools can detect not only local defects in lined gas pipelines but also features in the line, such as:

- General or one-sided wall thickness variations.
- Pipe material property (magnetic permeability and electrical conductivity) variations.
- External objects, such as pipe supports.
- Bends, wrinkles and dents.
- Stress due to soil loading or ground movement.

Each of these features in the line gives a unique indication in RFT data. As an example, magnetic permeability variations and pipe bends gave distinct signatures in the RFT signal, as shown in Figure 4. The first strip chart from the left in Figure 4 is the signal's 'time of flight' (green) and amplitude (red) of detector array. Shown in second strip chart is detector array time of flight data superimposed on the same chart line. This fanning in the second strip chart is typical signature of a pipe bend. The third strip chart is the Y-component plot for the detector array, and the right-most strip chart is the colour map representation of the second strip chart data. When the same raw data is analysed in a voltage plane polar plot (VPPP), each feature can be identified easily. On top and bottom part of the strip chart are the natural magnetic permeability variations introduced during the pipe manufacturing process.

Corrosion products, such as magnetite, can grow in volume in annulus between liner and pipe wall and bulge the relatively soft HDPE liner inwards. In the worst-case scenario, the liner can collapse due to volumetric growth of the corrosion products. Prior to RFT inspection of any HDPE-lined pipeline, a gauge pig will be run through the pipeline to detect any internal restriction caused by liner bulge or collapse. Pipe ID restriction due to liner inward bulging or collapsing was detected over relatively long distance within the pipeline in the past. Usually this situation is addressed by pulling out the damaged liner and relining the section of the pipeline in question. If the pipe section is severely corroded, the section of the pipe will be replaced too.

Summary

RFT technique is increasingly deployed as ILI technique for oil and gas pipelines. Some oil and gas pipelines cannot be inspected by conventional NDE techniques, such as those with thick internal HDPE liner. These pipelines can be best inspected by RFT ILI tools primarily due to their tolerance of large clearance between sensors and pipe wall.

Past inspection jobs for lined sour gas pipelines have demonstrated the feasibility of RFT in pipes where thick internal liners created large tool liftoff between tool sensors and pipe wall. Even at such large liftoff, the RFT inspection tools showed high sensitivity to pitting defects as well as features in the pipeline. WP

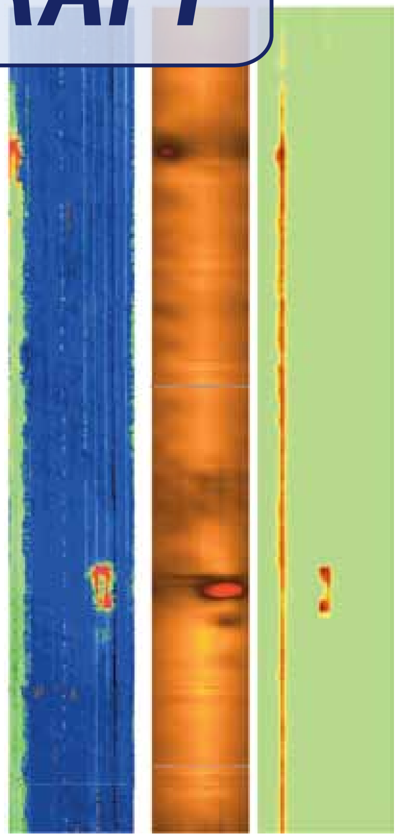

Figure 3. Comparison of RFT results with AUT and TT data for an exhumed 6 in. sour gas pipe.

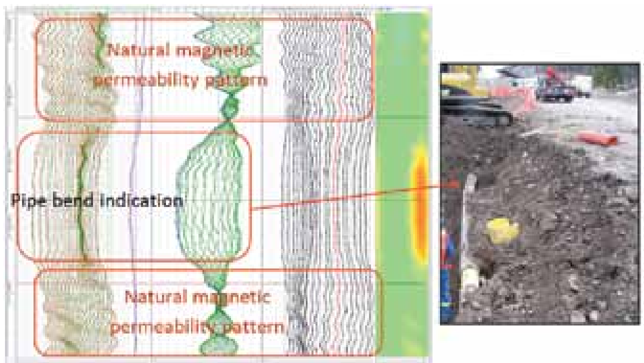

Figure 4. A section of sour gas line with a bend and magnetic permeability pattern.

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