BETTER INSPECTION DATA MEANS BETTER TANK MANAGEMENT

Stuart Kenny from Eddyfi explains the benefits of magnetic flux leakage systems for tank floor inspections

ABOVEGROUND storage tanks are subject to obligatory and periodic inspection routines. Due to the harsh operating environments and the catastrophic impact of failure, storage facilities are governed by regulatory practices to ensure the assets are fit for service. This is a well-established integrity management consideration, and many non-destructive testing (NDT) service companies around the world have adopted similar methodologies for this type of inspection.

There are numerous potential damage mechanisms associated with the in-service operation of tank storage, and each risk of failure requires careful management and routine inspection. Underfloor corrosion is specifically related to the soil interface underneath the tank floor. Regarded as one of the most significant threats in tank storage, floor corrosion is often identified as a risk during integrity management programmes. Inspection of this potential defect will regularly be included within the written scheme of examination/inspection.

MAGNETIC FLUX LEAKAGE

Given the large service area of a tank floor, the typical in-service condition of the scanning surface, and the general working conditions inside a storage tank, the inspection method identified to detect underfloor corrosion must be fast, robust, reliable, and provide a high value of confidence for minimum detectability. Magnetic flux leakage (MFL) systems have been historically deployed for this part of the inspection process, and the technology has a proven track record for being able to provide consistent results within these harsh and uncomfortable environments. MFL as a technology has numerous deployment applications; however, this article specifically considers the use of hall effect sensors to measure flux leakage changes in order to determine the severity of corrosion.

In simple terms, MFL uses a very powerful magnet to introduce a magnetic field into the component under test, the tank floor in this case. When saturated with a magnetic field, any changes within wall thickness will disturb the lines of flux, and where there is a wall thickness reduction, will cause the fields to 'leak' out of the test surface. These leaking fields have correlation to a discernible amount: the more corrosion present, the more fields will leak. The hall effect sensors are then able to determine the severity of the damage.

As with most NDT methods, the true physics of MFL have been around for decades and the philosophy of introducing a magnetic field into a test component has been used across many disciplines over this period. Although the general principles remain the same, advances in technology in terms of sensor sensitivity, signal processing, and software algorithms offer significant advancements in MFL tank floor scanners of today compared to their predecessors.

TODAY'S TANK FLOOR SCANNERS

The FloormapX from Eddyfi Technologies is a good example of how the basic principles of MFL physics have been pushed to the limits to allow users to improve the reliability of inspection in terms of minimum defect detectability, while also producing high-resolution images to increase the confidence level of the asset owner. The most advanced systems of today can generate high quality C-scan images that not only detect levels of corrosion, but also paint a picture of the precise condition of the tank floor. In addition to the increased confidence of providing fully mapped tank floor bottoms, having these high-resolution data sets recorded and archived allow asset owners to compare periodic data sets to make calculations on corrosion rates and determine the remaining life and fitness for service of their assets.

The latest software packages are also equipped with assisted defect recognition algorithms that can automatically list defects depending on a predetermined threshold level. For example, if the asset engineer is concerned with defects that are greater than 20% wall thickness loss, this information can be uploaded into the acquisition software and any defects that fall into this category are automatically listed with the exact location of the area of concern recorded. This powerful assistance improves the total overall efficiency of the inspection and helps guide operators to locations where supplementary NDT can be performed.

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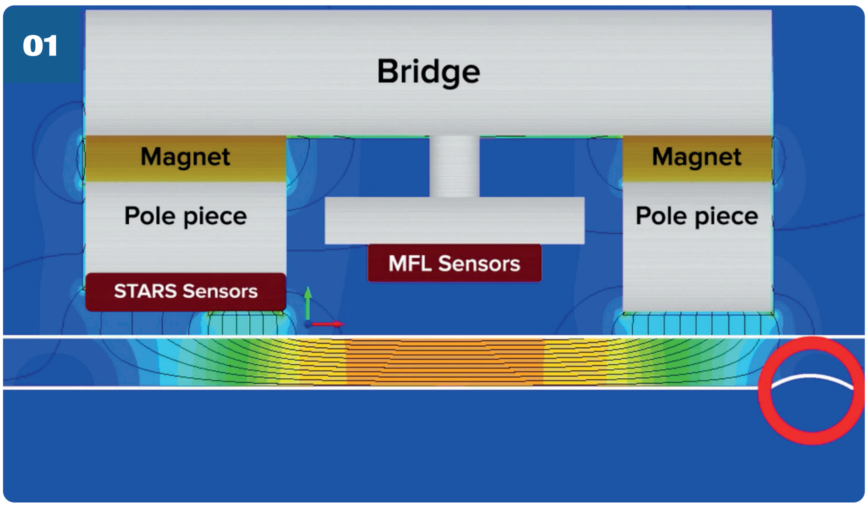


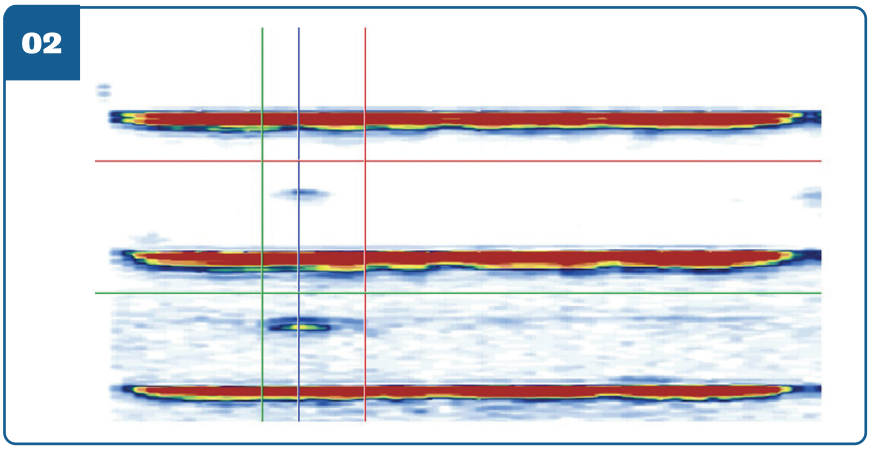
PRECISION DATA

The FloormapX is also equipped with patented STARS technology that uses the same magnetic induction, however instead of the hall effect board, it uses a different set of sensors to determine if the corrosion is topside or underneath. This powerful addition is particularly important when considering the inspection of coated tank bottoms as a visual inspection to determine the surface origin of the defect is not possible. Combining the information from STARS and the hall effect sensors, the software is also able to automate the defect listing, now showing the X-Y coordinates of the defect, but also automatically determining the surface at which the corrosion originates from.

The FloormapX has mechanical features that maximise coverage of the tank floor and reduce the amount of supplementary NDT methods needed. For example, the FloormapX has motorised steering capabilities that allow the system to drive around a curvature. This is particularly important when inspecting the critical zone of the tank, which is typically the annular plate area adjacent to the shell. The annular plate is the plate directly connected to the tank shell and is regarded as 'critical' due to the load bearing associated with the weight of the outside of the tank. Considering the criticality of this area, the inspection campaigns are often focussed on gaining the most amount of data in this zone. Until the advances in mechanical design and the nature of the powerful magnet, getting MFL systems close to the tank shell was very difficult. The motorised steering and careful shielding of the magnet in the FloormapX design allows operators to scan as close as 12 mm to the annular weld, therefore significantly reducing the time in a tank.

ENSURING EFFICIENCY AND ACCURACY

With all the above considered, advanced MFL systems have significantly improved the overall efficiency of tank inspection while providing confidence to the asset owner that the smallest of corrosion areas do not go undetected. However, MFL —as with all NDT methods— has its limitations; being a comparative volumetric method, the sizing algorithms are based on comparing signals against calibration traces. During operations, MFL users will carry out a calibration scan on reflectors that are machined to replicate the shape of corrosion. They are volumetric in nature and machined to different depths, typically 20%, 40%, 60%, and 80%. These calibration traces are recorded within the software. When performing the tank floor inspection, the software will compare any signals from corrosion with the calibration responses, therefore providing a percentage wall loss measurement.



To ensure accuracy of these signals, operators will often prove up a certain percentage of these indications with an ultrasonic testing (UT) method. This will then be recorded within the software as well. UT is widely recognised as the most accurate NDT method for determining wall thickness and uses time-of-flight measurements to measure any material losses. UT is however limited to single lines of data and only provides tabulated thickness results. It is becoming increasingly popular to use advanced UT methods such as phased array UT (PAUT) to supplement the original MFL data.

MFL tank floor scanners can cover large areas very quickly, detect small areas of wall loss, and are less affected by surface condition. Using PAUT as a supplement can maximise productivity and provide fully quantitative data sets and high-resolution imaging. Because phased array is a cross-sectional method that can display three orientations of data sets and provide accurate thickness results, the operator can accurately determine the morphology of defect types, and very importantly, differentiate between corrosion and other defects. For example, some old infrastructure has poorly manufactured steel and inclusions can be found within the steel wall. As MFL is volumetric, it will locate inclusions very well, but it is the cross-sectional view of phased array data that can determine if the volumetric indication is connected to the surface or if it is embedded in the floor.

In conclusion, magnetic flux leakage technology has significantly advanced in recent years and software capabilities ensure productive workflows and high-resolution data sets. As with all non-destructive testing, there are often inspection requirements that fall out of scope; supplementary methods such as phased array can enhance the overall integrity assessment, thus allowing for more detailed decision making to ensure a robust storage tank management programme.

For more information:

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01 MFL bridge components. The red circle shows magnetic flux being affected by presence of a corrosion pit

02 Phased array ultrasonic testing (PAUT) inclusion

03 FloormapX performs curved scan at shell annular