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Factors affecting the reliability of Magnetic Flux Leakage Surveys of Above Ground Storage Tank Floors.

Introduction

Over the past 10 years the preferred method for the inspection of Above Ground Storage Tank Floors has proven to be by the Magnetic Flux Leakage method. Unfortunately, the service companies, in their zeal to open up the market, have been less than forthcoming with some of the limitations of this particular application of MFL. This has led to some confusion within the industry as to what this inspection method is capable of achieving. There are too many stories in circulation about significant defects being underestimated or missed completely.

In the following paragraphs I shall attempt to describe some of the limiting factors in this application of Magnetic Flux Leakage so that the reader can better understand what to expect from this Inspection Technique.

Limiting Factors

(A) Adjustment of Equipment

It is vital that the equipment is adjusted in accordance with the manufacturers recommendations. These adjustments will vary in relation to both thickness of the plate to be inspected and the thickness of any coating. In order to create leakage fields from corrosion it is necessary to achieve near saturation of the magnetic flux in the material. If near saturation does not exist then no leakage field will be generated and therefore there will be nothing for the sensors to detect.

(B) Surface Condition

The top surface condition of the plate to be inspected absolutely dictates the achievable level of sensitivity of the inspection. The rougher and dirtier the surface, the more noise that will be generated from the inspection process and the lower the achievable sensitivity. Real signals will be masked by the level of noise generated.

(C) Plate Curvature

Tank floors are never flat. The degree of curvature of the plates can have a significant impact on the reliability of the inspection. When the curvature of the plate causes an increase in lift off by either the magnetic bridge or sensor the sensitivity suffers dramatically. This can be often be overcome by scanning in more than one direction. Curvature of plates close to lap joints and/or the shell can make it virtually impossible to scan these areas reliably. In some cases smaller scanning heads can be used to overcome this problem.

(D) Material properties

The material itself can also have a significant impact on the inspection. Most floor plates are manufactured using low carbon steel, which lends itself very well to this technique. Higher grade materials require a much higher magnetizing force to achieve the same levels of saturation. This also applies to materials whose properties have been degraded by the service. i.e. Sour Crude Storage. In this case the material suffers from hydrogen attack and it may not be possible to achieve the necessary flux saturation of the material to achieve the required sensitivity. This can also be a major contributor to noise levels. The direction of rolling can also have an impact on the amplitude of signals from the same sized corrosion pit. It has also been noted that noise levels can vary even on clean smooth surfaces due to either variations in the material properties or method of manufacture.

(E) Accessibility

It has often been claimed that MFL can achieve 100% coverage of the floor area. In reality this is virtually impossible to achieve due to the overlapping nature of the plates and the number of obstructions in most floors. It is also difficult to inspect adjacent to the shell because of the curvature. There are often many areas of the floor that are inaccessible to the regular scanners. Smaller scanning heads can be used to alleviate some of this problem but it is rarely possible to cover the entire floor using MFL alone.

(F) Product side/Underside Discrimination

Magnetic Flux Leakage is incapable of reliably discriminating between product side and underside corrosion. In most cases this is not a problem as it is possible to discriminate signals visually. In the case where there is a known topside problem that has been documented and passivated (by coating) after an earlier inspection and removal of the coating is not necessary then it is helpful to the inspection agency to have access to the earlier inspection information. This can speed the inspection process significantly. The very nature of MFL means that in some cases product side corrosion can not be detected by the floor scanner. As a general rule the response from a product side pit with the same volume loss as an equivalent underside pit will be significantly less. This is due in part to the higher flux leakage levels being retained within the depth of the pit itself whereas on the other side (underside) of the ligament the leakage field will be above the surface and therefore in the direct path of the sensors.

(G) Coated Floors

In addition to the above limitation and in the case of thicker coatings there is another factor that affects achievable sensitivity. While it is often possible to overcome the additional lift off of the magnetic bridge by lowering it within the carriage the same cannot be done with the sensor array to place it as close to the surface as possible because the coating is in the way. This obviously means that it will no longer be possible to achieve the same levels of sensitivity that could be demonstrated on the uncoated plate of the same thickness. In all such cases it is necessary to run a simulation prior to the inspection to see what can be achieved.

(H) Thresholding

Many manufacturers employ a thresholding approach to this application in order o semi-automate the inspection. MFE Enterprises Incorporated do not support this approach and feel that this is the major reason why significant defects have been missed. The amplitude of signals generated from corrosion pitting is more a function of the overall volume loss than the remaining wall thickness. Defects exhibiting largely different amplitudes can have the same through wall dimension. Couple this with the need to control and monitor all the inspection parameters (virtually impossible in this application) and it means that this approach is seriously flawed both theoretically and in practical terms. MFE Enterprises provides a real time display that must be monitored by the operator. Any time that he sees a discreet signal above the noise level the location must be marked and the indication further investigated. Failure to do this can result in significant defects being missed.

(I) Corrosion Mapping of Flux Leakage Signals

Systems that use a multiple threshold and supposedly accurately map the results in the form of a color coded output related to wall thickness are available on the market. It is fashionable to computerize everything these days. Unfortunately this is one application that suffers by this approach. First of all, Magnetic Flux Leakage is incapable of accurate quantification of remaining wall in this application owing to the volumetric nature of the defects and, secondly, it is not possible to filter out all the spurious indications from anomalies, other than corrosion, on the fly. The maps are often misleading and inaccurate containing good and bad data with no way of discriminating between the good and the bad. It does, however allow the manufacturers to charge a much higher price for the equipment and call it “State of the art”!

(J) Operator

As with any equipment the operator is responsible for it’s correct use and the validity of any inspection is absolutely dependent upon his integrity. I would rather have a good operator with the worst equipment rather than a bad operator with the best equipment. At the moment, ASNT does not offer a qualification for MFL specifically. All operators should, as a minimum, be able to show proof of training in the use of the equipment they are operating along with a reasonable understanding of the technique. MFE Enterprises provides this training free of charge other than for the reimbursement of expenses. **NO TWO PIECES OF EQUIPMENT ARE THE SAME**. It is imperative that the end user goes for the best equipment and a good level of confidence in the person using it if they want to get the best inspection possible. This is not the type of equipment or technique that can be made idiot proof.

(K) Commercial pressures

No two tank floor inspections are the same and range from smooth, clean, flat and defect free to rough, dirty, buckled and corroded throughout. It is obvious that a good inspection of the latter is going to take significantly longer and require more effort than the former. If the industry understands this then why are most of these inspections bid on a lump sum basis? It is impossible to foresee the amount of time and effort involved. A tight bid on a bad floor with extensive corrosion is bound to put additional pressure on the contractor. It may be financial suicide for him to spend more than the allocated time on that particular project. What normally happens in a case like this is that some of the corrosion detected goes un-reported as the contractor tries to make the best of a bad job. As we have already discussed, if he decides to select on the basis of amplitude of signal it stands to reason that significant defects will be overlooked. The only time you find out about the ones that are missed is when the floor leaks! This should not happen if the inspection is based on time and material with the end user taking some responsibility for progression of the work. Invariably the best inspections are carried out by this method.

Conclusion

Anyone reading this most probably feels that there is no hope especially if they have experienced problems in the past with this application of Flux Leakage. There is a great deal of hope, however. On a daily basis hundreds of tank floors are being successfully inspected by competent well trained operators using reliable equipment who have a full understanding of the above and are not afraid to mention the limitations of the technique. There is nothing else out there that can compete with the reliability and speed of Magnetic Flux Leakage provided that the technique is properly applied and that all the limitations are fully understood.