Comparison of MEC and MFL Technique for Tank Floor Inspection

This document describes the difference between the MEC (Magnetic Eddy Current) technique and MFL (Magnetic Flux Leakage) technique, predominantly for the tank floor inspection application.

Principle of MEC Technique

The MEC (Magnetic Eddy Current) technique is the next generation and a further development of the SLOFEC (Saturation Low Frequency Eddy Current) technique. The MEC technology works with a combination of direct current magnetic field Lines and Eddy Current field lines. The principle of the technique is that a direct current magnetic field is induced into the steel wall to be inspected to a level along the hysteresis curve called the Retentivity Point which is way below the magnetic saturation level of the material.

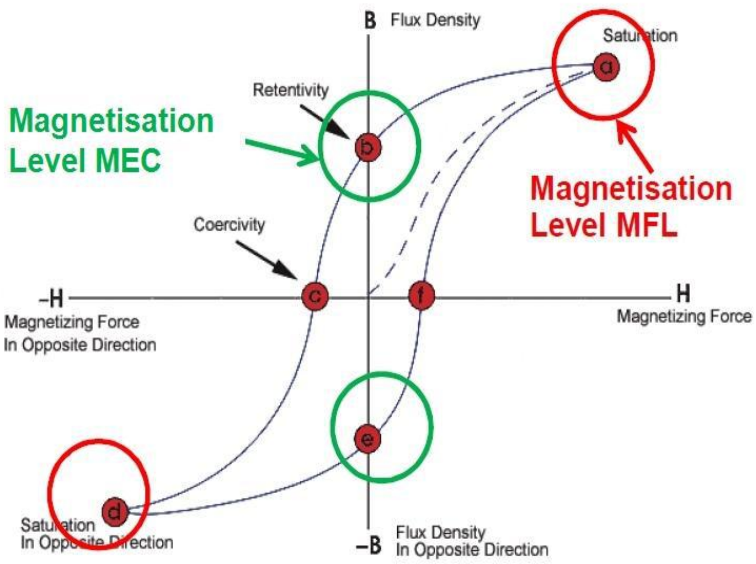


Figure 1: Hysteresis curve displaying the level of magnetisation requirement for the MEC technique versus MFL technique

In case of defects on the far side of the steel wall, the direct current magnetic field lines have an increased density in the remaining wall thickness of the material. The additionally induced alternate Eddy Current field in the area then changes due to the change of the direct current magnetic field density.

While the defects on the far side of the material have an effect first on the direct current magnetic field and consequently on the Eddy Current field, the defects on the near side of the material directly affect the Eddy Current field. Due to the different Eddy Current field responses, the indications are almost 90 degree in signal phase difference between far side and near side defects which are therefore well distinguishable.

Innospection Limited
Unit 1, Howemoss Avenue, Kirkhill Industrial Estate, Dyce, AB21 0GP, Aberdeen, United Kingdom
Tel : +44 (0)1224-724744 Fax : +44 (0)1224-774087
Web : www.innospection.com Email : info@innospection.com

As the Eddy Current signal window has a wider spread, even the signals of surface debris (such as rust), inclusions and laminations can be distinguished from the defects. This reduces and eliminates false calls enormously. As a result, the MEC technique often requires lesser surface cleaning and preparation than the MFL technique.

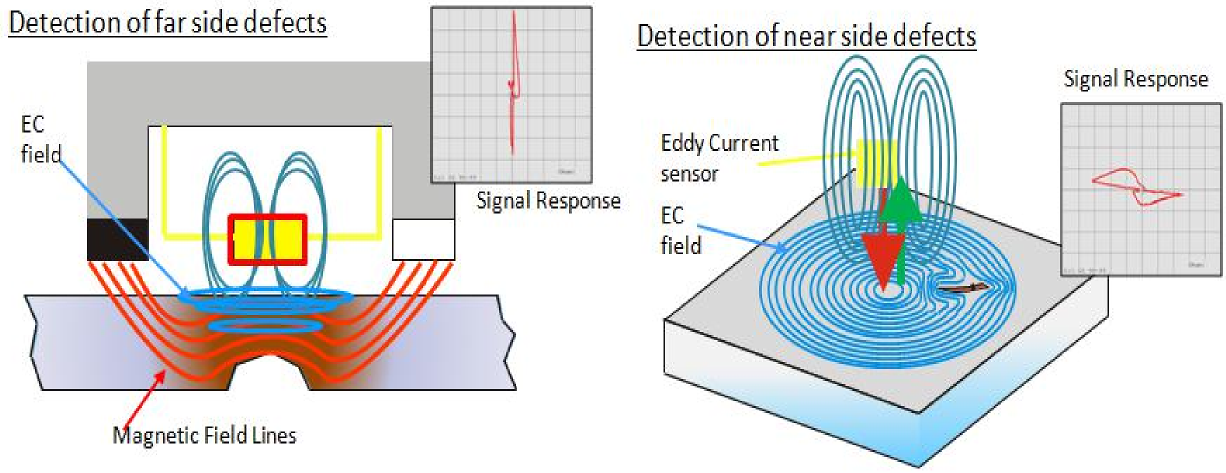


Figure 2 – Principle of MEC (Magnetic Eddy Current) technique

The fact that the MEC technique works with a direct current magnetic field strength that is below the magnetic saturation level enables the MEC technique to operate at higher wall thickness (typically to 1" or higher).

Like the Eddy Current technique, the MEC technique has an active sensor system and the field induced to detect magnetic field changes happens actively "inside" the material wall. As a result, the technique can easily overcome increased equipment lift off / distances e.g. coated surfaces and in some cases up to 15mm.

The Eddy Current sensors enable the display of a complex impedance signal for the following analysis:

- Signal phase : to determine far side defects, near side defects, inclusions, debris, etc
- Signal amplitude : for information on the detected wall loss
- Signal pattern : for information on the defect size

The multiple sensor arrays integrated into the equipment enable higher resolution for the direct sizing of the detected defects. The design of the MEC Scanners such as the MEC-Floorscanners enables the scanning very close to borders such as scanning close to the shell of a storage tank.

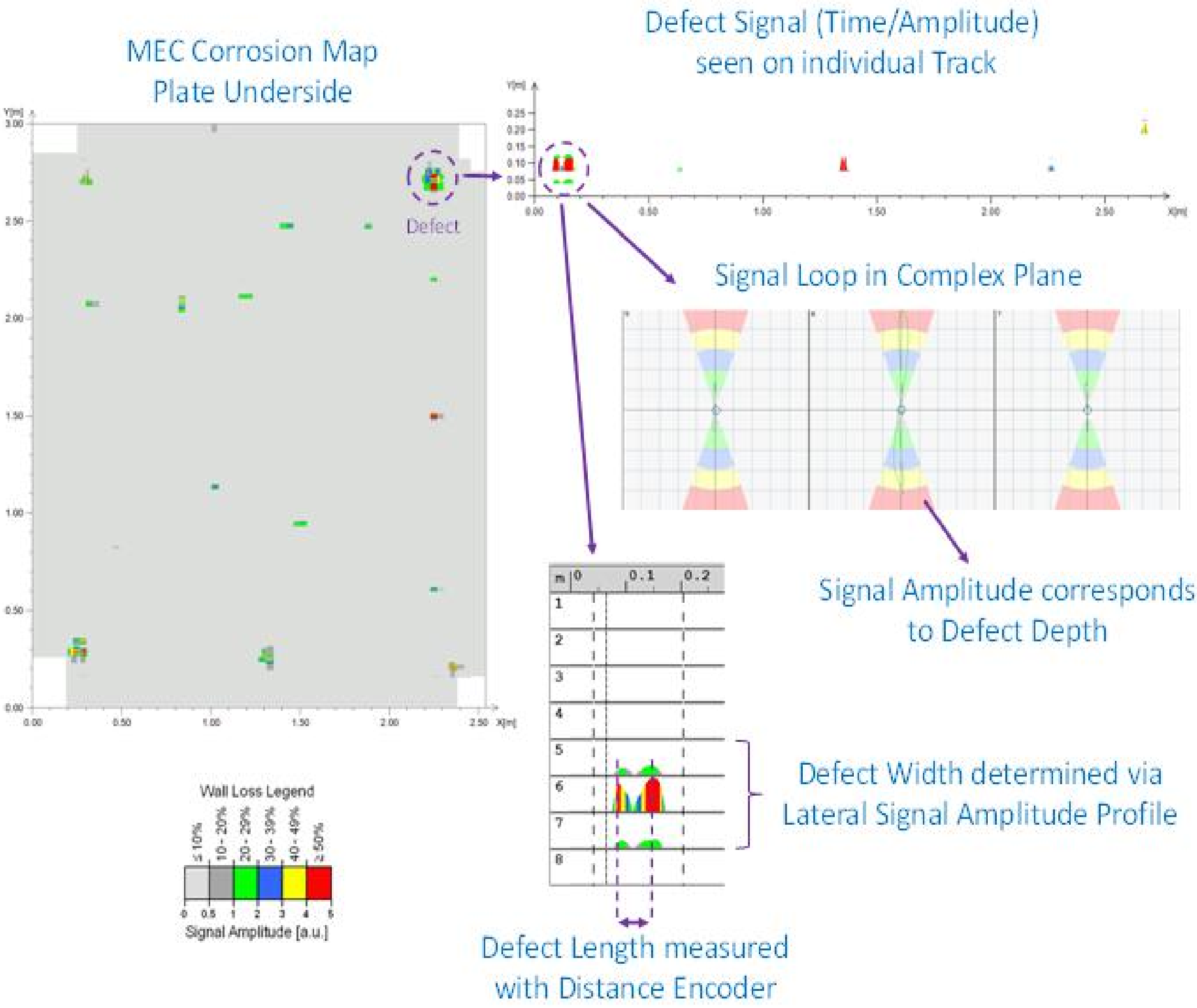


Figure 3: Corrosion mapping and defect sizing of the MEC (Magnetic Eddy Current) technique

The MFL Technique

The MFL (Magnetic Flux Leakage) technique induces direct current magnetic field lines into the steel material to be inspected with the target to detect the stray flux on the “outside” of the material wall by the hall sensors. The magnetic flux lines are distorted in the presence of a defect in the steel. Hence, they leak out of the metal and lead to a magnetic field near the steel surface which is picked up by the Hall sensor.

The steel wall has to be saturated in order for the magnetic field line flux to lead to a relevant flux leakage, which means that the direct current magnetic field lines have to be very strong to reach the saturation level in the material.

As it typically requires a very strong magnet to reach the magnetic saturation level in the steel wall, the available magnet scanners are usually limited to operate on low wall thickness. In order to achieve the magnetic saturation level, it is also important that the magnet poles are very close to the material surface, which permits realistically to operate on top of coated surfaces.

In the event that the magnetic saturation level is not reached, it can typically result in false calls due to the fact that the slight Relative Permeability variations in the steel cause the magnetic field level to change and therefore induce a flux which provides the voltage induced in the hall sensor (coil). This cannot be distinguished from real defect indications and consequently false calls may occur. Surface magnetic debris can also generate a flux situation and consequently result in false calls.

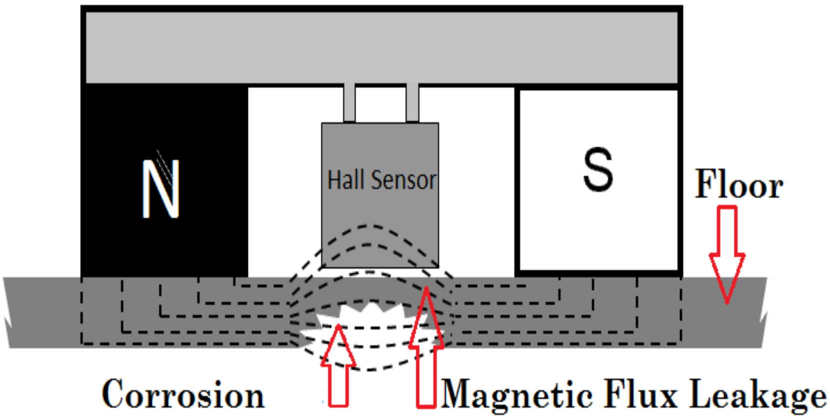


Figure 4: Principle of the MFL Technique

In order to receive the flux induced from the steel surface at the hall sensor (coil), it is to be ensured that the sensors are close to the surface. The flux field outside the material loses strength quickly over distance which means that the sensors have to be as close as possible to the steel surface. This often limits the inspection of coated surfaces with even lower wall thickness of the materials.

The voltage measured in the hall sensor (coil) does not provide separate information of the defects on either side of the wall or distinguish between defect signals and false calls. It has also limitations on defect sizing. Thus, each severe indication detected by MFL is typically verified by Ultrasonic technique.

Therefore, it is important to understand the following points when using the MFL technique for inspection e.g. tank floor inspection:

- The magnetic saturation of the material is required to be reached; therefore,
  - the technique is limited to the plate thickness
  - wavy plates causing an increased magnet pole lift off consequently takes the level of magnetisation out of the saturation level
  - coated surfaces limits enormously the possibility of reaching the saturation level as the increased distance to the steel surface has an exponential decay of the magnetic field strength in the wall

- Distance of the sensors to the surface:
  - The sensors are required to be close to the surface to reach the voltage induction by the induced stray flux
  - Coated surfaces limit the detection of the stray flux
  - Cleanliness of the surface has be high to avoid debris causing false calls and increased stand off
  - Wavy plates cause increased distance of the sensors to the surface

- Principle of MFL
  - Direct analysis of defects on either side of the wall or false calls are not possible and require verification which is time consuming
  - Typical MFL scanners have design which leave large distance to the shell of storage tanks

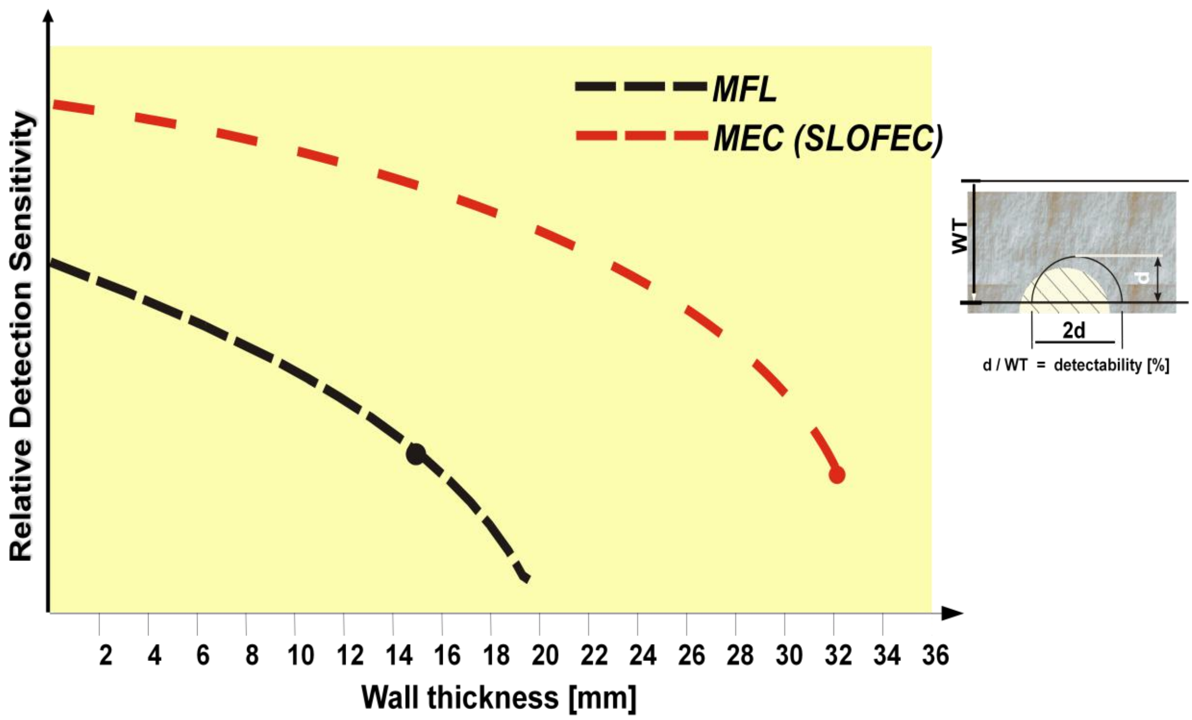
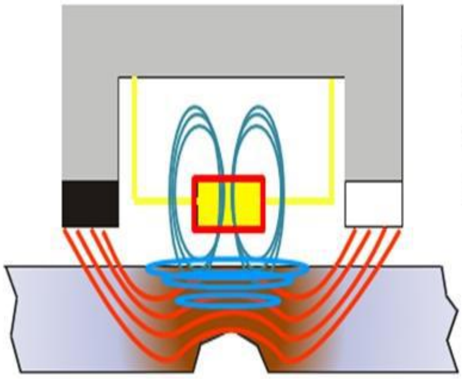
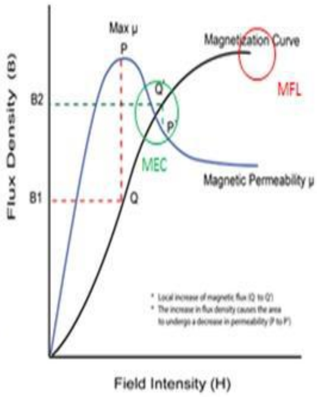


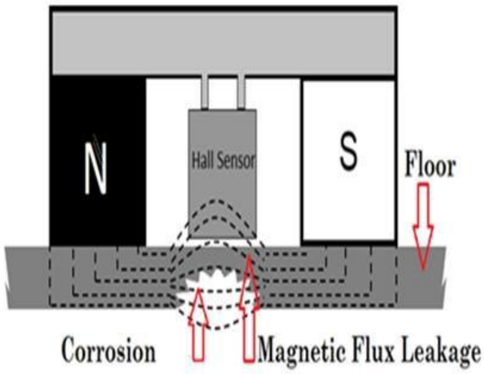
Figure 5: Wall thickness and detection capability comparison between MEC/SLOFEC Floorscanner versus MFL Floorscanner

Comparison between MEC and MFL

The tables below show the technical and principle key points of the MEC versus MFL technique.







A. Induces an active (Eddy Current) field in the material

B. Detects defects in the material due to field line density / relative μr change

C. Requires less magnetic field strength as no stray flux is required (only 1.4 T or 3 kA/m). Therefore, WT ≤ 1”, Coating ≤ ½”

D. Has three (3) analysis factors:
Phase for types of indications, amplitude for wall loss (severity) and signal pattern for size

A. Passive sensor (hall sensor)

B. Flux leakage is caused by defects and other inhomogeneities in or at the material and it induces a voltage in the hall sensor

C. Requires high magnetic field strength (1.8 T or 10 kA/m). Therefore, WT ≤ ½ ”, Coating ≤ 3mm

D. Has one (1) analysis factor:
Amplitude of induced voltage in hall sensor

The table below shows some key facts of MEC versus the MFL technique for storage tank floor inspection:

	MEC	**MFL**
WT	Up to 30mm (TÜV qualified 35mm)	Up to 10 mm (between 12 to 15mm)
Coatings	Up to 10mm, any type	Up to 2mm
Distinguish Defects / False Calls	Yes (by Signal Phase)	No
Distinguish (report) Topside from Underside Defects	Yes (by Signal Phase)	No
Material magnetic properties	Allows tolerances	Have to remain constant
Defect Detection Sensitivity	From below 20% wall loss	From > 20% wall loss
Shape of corrosion	Relative independent	More dependant
Saturation level in parent material remains constant	Only light influences as no saturation is required	Strong influences as saturation is required

Mapping	Yes (by Signal Phase) Topside / underside separate	Limited
Inspecting close to the Shell	Yes (by Signal Phase) Dead Zone ~ 20mm	-
Speed	20-30m/min; Independent of speed change	20-30m/min; speed change influences amplitude

Advantages of Tank Floor Inspection with MEC Technique

- High defect detection sensitivity for topside and underside corrosion and pitting
    - Typical at WT ≤ ½" – detects from Ø3mm to 5mm from 10% wall loss
    - Probability of Detection (POD) for pitting and corrosion of up to 95% which is of key importance for condition assessment and risk-based inspection programs
- Accuracy of defect sizing ≤ +/- 10% (in extended analysis +/- 5%)
- Ability to inspect lined and unlined stainless steel, carbon steel and aluminum tanks with plate thickness up to 30mm
- No coating removal or shot blasting required with inspection through coatings up to 10mm (equipment available to inspect up to 15mm coating)
- Ability to scan right next to tank shell with minimal dead zone at annular areas and plate overlaps
- Ability to detect corrosion at the overlapped welds in lined tanks
- High inspection speed – net average run speed is 0.25m to 0.5m per second
- Separate corrosion mapping of topside, underside and merged defects
- Direct online data assessment and reporting
- Minimum tank preparation prior to inspection i.e. tank only needs to be broom cleaned