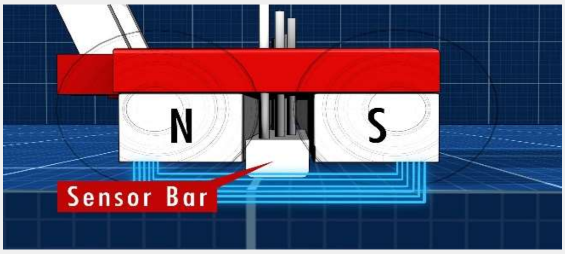
ABOVE GROUND
Storage Tanks

BOTTOM CORROSION DETECTION

MAGNETIC FLUX LEAKAGE EXAMINATION

WHAT is MFL?

Magnetic Flux Leakage (MFL) Examination is a method of non-destructive testing (NDT) for a ferromagnetic material; began to be widely used from the beginning of the 50s in the twentieth century and is the most popular methods of tank floor, pipeline, and tubular inspection. It is a qualitative test used to detect and assess corrosion, pitting and wall loss in lined and unlined metallic storage tanks and pipelines. A powerful magnet is used to magnetize the steel in areas where there is corrosion or missing metal, the magnetic field "leaks" from the steel. MFL tools use sensors placed between the poles of the magnet to pinpoint the leakage field. MFL is a rapid and robust approach that continues to be widely used to detect corrosion defects in Tank Floors as it considered a large area within short time scales. Once a defect has been detected, the main failing of the MFL approach is its inability to size and classify. To Verify and improve sizing accuracy, defect needs to be quantified and followed up by prove up using UT thickness with A scan features.



MEASURING METHODS & SENSORS:

1. **Electromagnetic induction method**. Based on Faraday's law of induction Coil, it is one of the most basic magnetic measurement methods.
2. **Magnetic resistance effect method**. This method utilizes the changing characteristics of material resistances under magnetic fields.
3. **Hall Effect method**. The electromotive force is generated by the electric current in the magnetic field. The change of the magnetic field intensity can be obtained by measuring the electromotive force.
4. **Magnetic resonance imaging**. By absorbing or radiating a certain frequency of electromagnetic wave in the magnetic field.
5. **Magneto optical method**. This approach utilizes the magneto-optical and magneto-stricture effects.

TANK BOTTOM DEFECTS & CORROSION:

In Oil & petrochemicals industries, corrosion is one of the main causes of catastrophes to structures and equipment. Atmospheric storage tanks, pressure vessels and pipelines are gradually corroded by chemical or electrochemical reactions within their environment.

The most common types of corrosion are pitting and uniform corrosion, especially pitting corrosion in low carbon steel. Low carbon steel is widely used as the main material for atmospheric storage tank floors, and the atmospheric storage tanks play an irreplaceable role in storage and transportation of crude oil and oil derivatives.

However, over 80% of the storage tanks shutdown, bottom perforation and leakage accidents are caused by tank bottom corrosion. This can cause very serious consequences on the environment, health and safety, producing a very wide range of hazards and disasters. Therefore, the storage tank bottom corrosion has attracted more and more attentions all over the world in recent decades.

UNDERNEATH PITTING CORROSION IN BOTTOM OF CRUDE STORAGE TANKS:

Soil-side corrosion of aboveground storage tank may be the main cause of tank failure, with thousands of Aboveground Storage Tanks (ASTs) installed, the MENA (Middle East & North Africa) region is not an exception. Ingress of chlorides and other corrosive species from the native soil and groundwater through the tank pad, along with the presence of bacteria such as SRB (sulfate-reducing bacteria), are believed to be the main causes for soil-side corrosion. Airborne chlorides and moisture can seep into the under-tank environment through the chime area, causing annular plates to corrode.

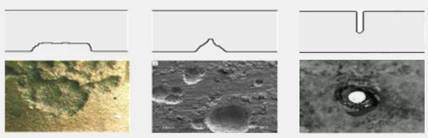
Underneath pitting corrosion is localized corrosion in bottom plates from soil side, this is most critical corrosion problem in tanks and it leads to bottom failure. Corrosion rate depends on the soil characteristics, moisture content in the padding and extent of water ingress between padding & bottom plates. Cause of pitting corrosion and embedded stone particle assisted crevice corrosion based on field & laboratory inspections and alternatives to mitigate the underneath corrosion effectively in future, are included in this paper broadly.

DEFECTS & CORROSION COMMON TYPES:

Corrosion comes in many different shapes and sizes grouped into three categories based on its geometrical shape:

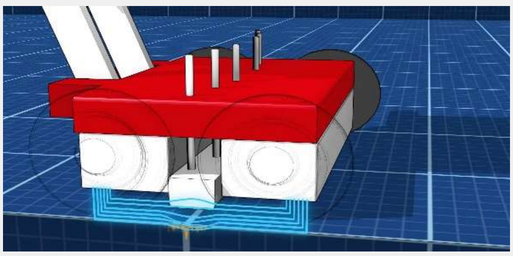
1) Lake (Dish shaped corrosion)
2) Pit (Conical shaped corrosion pits)
3) Pipes

Lake Type | Pit type | Pipe type



► Lake Type, have a large diameter compared to their actual depth.
► Pit / Conical Type, have some rounding at its deepest point.
► Pipe Type, have small diameter similar to the drilled hole.

As corrosion grows these basic shapes can join together, dish/lake shaped corrosion can be more difficult to detect due to the sloping edges. The MFL equipment will detect a change in plate thickness. Thus once the MFL inspection head is within a large area of corrosion the system can only detect further loss in plate thickness. It may be possible to detect the edges of such corrosion and with follow up ultrasonic thickness inspections determine that there is an area of general thinning due to extensive corrosion.



Continue MFL EXAMINATION

EQUIPMENT DESIGN CONSIDERATIONS:

EX. Tank Floor Scanner; the equipment shall consist of magnets, sensor or sensor array, and related electronic circuitry. A reference indicator, such as a ruled scale or linear array of illuminated light-emitting diodes, should be used to provide a means for identifying the approximate lateral position of indications. The equipment may be designed for manual scanning or may be motor driven. Software may be incorporated to assist in detection and characterization of discontinuities. ASME BPVC Section V, Article 16, T-1630

It is vital that MFL equipment produced for this particular application is designed to handle the environmental and practical problems which are always present. A piece of equipment designed in a laboratory and proved in ideal conditions invariably has significant short comings in the real world application. Some of the major considerations are discussed in the following paragraphs.

Some instruments can be disassembled for operation in and around obstructions or smaller surfaces. Alternatively there are some specific “hand scanning” devices for such requirements.

MFL scanning can be carried out in an automated manner, where information from a scan run is captured. This can be evaluated at this time or stored on a computer to build up an MFL picture of the whole tank floor. Subsequent analysis of the data can be performed out with the inspection environment. From these analysis areas for follow up UT inspections can be identified.

ADVANTAGES of MFL:

- Reliable results and ability to locate and estimate the size of defects over large areas in a quick and efficient manner.
- MFL covers a wide area not only random reading as conventional methods, which increase the (POD) possibility of detection of anomalies and reduce the remaining life assessment RLA.
- Saving time and cost due to the high inspection rate.
- Comprehensive reporting with statistical data, and color mapping.
- It can detect many types of defects. For example, surface defects, stomata, scars, shrinkage cavities, corrosion pitting
- Automated Corrosion Mapping Reporting & Data Analysis.
- Immediate result “Real time Display”.

MFL in INTERNATIONAL CODES & STANDARDS:

- API 653 Standard - Tank Insp., Repair, Alteration and Reconstruct.-ANNEX G
- ASME BPVC Code - Section V – Nondestructive Examination - Article 16
- ASNT Volume 5 - Electromagnetic Testing
- The MFL Compendium – Published by API & ASNT

MFL APPLICATIONS:

- **Storage Tank Floors (AST)** (lined and unlined metallic bottom):

MFL is a widely used to detect corrosion in above ground storage tank floors (ASTs) within the oil industry where tank floors are inspected periodically, the AST to be taken out-of-service and emptied. This makes maintenance times that much more expensive and calls for techniques that are both reliable and fast. MFL is widely used in the context because of its inherent speed. MFL is accepted technology for locating defects on a tank floor. It is recommended by API 653 & ASME.

- **Pipeline External Inspection** (lined and unlined metallic):

MFL is a widely used to detect corrosion in pipelines externally within the oil industry where it inspected periodically, the pipe can be inspected while in service. MFL is widely used in the context because of its inherent speed.

- **Pipeline Intelligent Pigging:**

MFL Pig is a type of intelligent ILI pig used to measure pipe corrosion and metal loss.

- **Tubular Inspection**:

The MFL is used to detect circumferential cracks, wall losses, and pitting in ferromagnetic tubes such as carbon steel, nickel and ferrous stainless steel for Air cooler, Boilers & Heat Exchanger.

- **Wire Rope Inspection:**

The MFL measurement instrumentation supposed to be designed for detecting local faults (LF) & loss of metallic area (LMA) in external or internal layers of the wire rope.

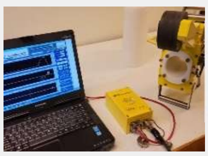
SPOT ON SOME MFL EQUIPMENT:

- Ex. 1: **Storage Tank Floor Inspection.**

MFL MARK IV & EDGE SCAN

- Ex. 2: **Pipeline External Inspection.**

- Ex. 3: **Wire Rope Inspection.**



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MARK IV

MFL Tank Floor Scanner