New Tech SYSTEMS

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MAGNETIC WALL

As a manufacturer of "electro-magnetic wall monitoring" systems (EMI Wall), we often encounter fallacies and "myths" concerning their capabilities and operational characteristics. The following is a report on magnetic wall monitoring and its use in the OCTG industry.

GENERAL

Unlike typical magnetic flaw detection systems (EMI Flaw) that are designed to detect FLUX-LEAKAGE fields, EMI Wall systems are generally used to measure the FLUX DENSITY within a magnetizing coil.

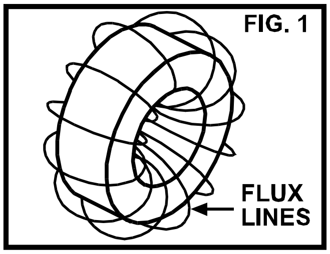


FIG. 1

When an electrical current is passed through a conductor, a magnetic field is established in and around the conductor. The strength of the magnetic field is proportional to the amount of current. In the case of a coil, the more times the conductor is "looped" in the coil--the stronger the magnetic field in and around the coil. The magnetic field strength (flux-density) is measured in "gauss." Gauss is a term used to express the number of magnetic flux lines per square centimeter (the higher the number--the stronger the magnetic field.)

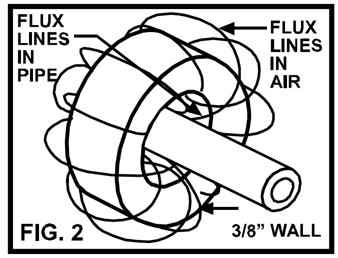


FIG. 2

Magnetic flux lines 1) follow the path of least resistance, 2) always form closed loops, and 3) never cross. They also CANNOT be nondestructively measured in a ferrous tube in standard field tests; only the magnetic field in AIR in the coil or around the tube can be measured.
When a magnetizing coil is turned on, the magnetic lines of force will travel in air around the coil (perpendicular to the current direction.) - **FIG No. 1**. In pipe inspection, whenever a ferrous piece of pipe is placed in a magnetizing coil, magnetic lines of force within the coil will travel in the material as the ferrous material offers a lesser path of resistance. With a given test configuration (coil, fill-factor, pipe placement within the coil, etc.), the number of magnetic flux lines that travel in the pipe and not in the air is dependent on the permeability of the pipe and the total amount of pipe (mass) in the coil - **FIG No. 2**.

MEASUREMENT

In EMI Flaw detection, search coils or hall-element sensors are usually used to detect flux-leakage. Flux-leakage is found wherever there is a change (generally abrupt) in a magnetized material's permeability (ease of which the material is magnetized) or the cross-sectional area indicating a discontinuity (crack, pit, etc.) in the pipe. In an EMI Wall measurement system, hall-elements are usually used to monitor a less abrupt change in section thickness by monitoring the change in the magnetic field outside the pipe.

There are 2 kinds of EMI Wall measurement systems commonly used - 1) An AC-coupled wall system, and 2) A DC-coupled wall system.

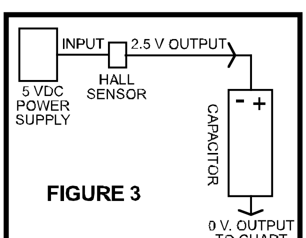


FIGURE 3

AC-coupled - The output of a hall-element is directly proportional to the input. If a hall-element is excited with a 5 volt power supply, the output voltage (OV) will be approximately 2.5 volts. The OV changes when the hall-element is placed in a magnetic field and oriented at an optimum angle to the magnetic field direction produced by the coil. The change in the magnetic field strength

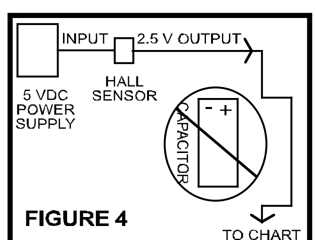


FIGURE 4

inversely affects the OV of the sensor. On AC-coupled systems, a capacitor is commonly used to remove or "zero" the OV of the hall-element - **FIG No. 3**. This limits the AC-coupled systems to detecting only those changes in material cross sectional area or permeability that occur quick enough so as not to be absorbed by the capacitor. In other words, a wall loss can only be detected dynamically and not statically.

DC-coupled - The OV of a Hall-element is read directly. When this occurs, the capacitor used in the AC-coupled method is removed - **FIG No. 4.** This allows for a measurement of the cross sectional area and permeability of a pipe where the change is either quick or slow (dynamically and statically).

BENEFITS/DISADVANTAGES

AC-coupled Benefits - 1) The base line appears more consistent as the capacitor is constantly "zeroing" the signal that goes to the chart. **2)** The visual effects of magnetic flux-leakage at the end of a tube (commonly called the "end-effect") are minimized for the same reason.
AC-coupled Disadvantages - 1) Small and/or large areas of wall loss that occur "gradually" over an area are not detectable. **2)** Extreme wall differences between one tube and another (as with different pipe weights) are not detectable.
DC-coupled Benefits - 1) Ability to detect areas of wall loss that occur "gradually" (such as OD wear in used drill pipe). **2)** Ability to detect differences in pipe wall thickness or pipe weights between one joint and another. 3) Ability to detect large differences in pipe permeability thus giving an indication of a grade change.
DC-coupled Disadvantages - 1) Magnetic end-effects are more noticeable. 2) The base line fluctuates as permeability and wall thickness vary - possibly giving an indication of a drifting baseline.

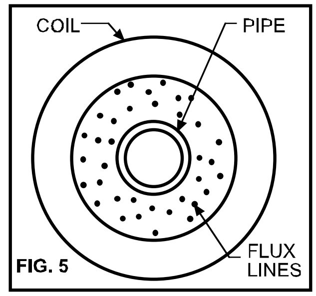


FIG. 5

Example: In **Figure No.5**, the flux-density reading (in air) would be less than the flux-density reading in **Figure No.6** due to thinning (loss of mass) on the ferrous tube (figures are exaggerated and flux-density shown is not proportionate or to scale).

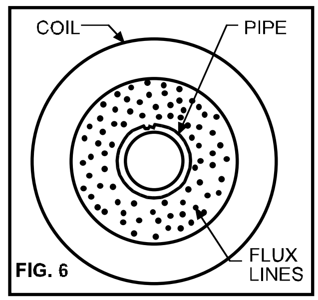
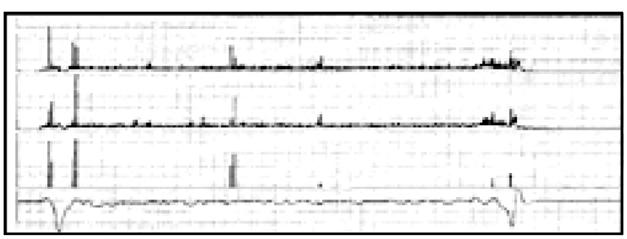
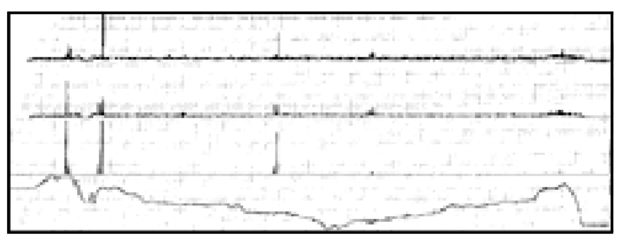


FIG. 6

The following 2 charts ran on a piece of 3 1/2" drillpipe. The same buggy head, coils, and cables were used. The same type of EMI system was used - however - one system had an AC-Coupled EMI Wall system and the other had a DC-Coupled EMI Wall system. Note the mid-tube gradual OD wall loss illustrated on the DC-Coupled wall system not shown on the AC-Coupled wall system. This is indicative of a typical joint of used drill pipe that wears more in the center than towards the ends due to the whipping motion in the rotary drilling process. [Large spikes on left indicate upset.]





MISCONCEPTIONS AND MYTHS

Misconception/Myth #1 - EMI Wall systems measure pipe wall thickness.
One may notice that usually the term "wall monitoring system" or "hall wall system" is used instead of wall thickness. This is because there are several major variables in an EMI Wall system that drastically affects the integrity of the process:

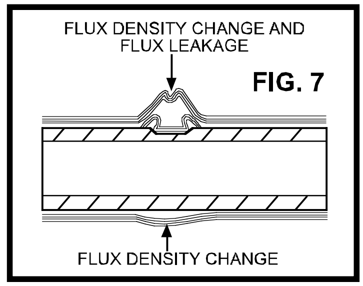
1) Permeability - The permeability of a pipe affects how easily it can be magnetized. Due to variations in material hardness and chemical composition, the permeability can and will vary. This will cause a change in the magnetic flux-density thus giving an incorrect indication of a thinning or thickening of the pipe wall.

2) Mass - If the pipe is eccentric (thin on one side and thick on another), there will be little or no flux-density change as opposed to the same tube with a nominal wall. An EMI Wall system measures cross-sectional area. A give wall loss of 5% that is 360 degrees around the pipe will cause the same change in magnetic flux-density as a 10% wall loss that is only 180 degrees around the pipe. It is the total ferrous mass in the coil that affects the amount of flux-density in the air.

3) Flux-leakage - While EMI Wall system sensors are oriented so as to optimize the measurement of the flux-density field inside the coil, because magnetic flux lines do not cross, a local leakage field will have a small or large effect on the flux density in the area of the leakage field. This is dependent on the amount of flux-leakage and its proximity to the EMI Wall loss sensor.

Essentially, EMI Wall systems are capable of showing a change (either gradual or more abrupt) in the magnetic flux density. This may or may not be due to wall thickness. Example - An N80 grade of pipe with 12-1/2 % wall loss may give the same indication as a P110 grade of pipe that has nominal wall.

Misconception/Myth #2 - EMI Wall loss systems can detect wall loss in quadrants. As the flux density changes due to a change in thickness on one side of the pipe, it changes throughout the active area of the magnetizing coil. It does NOT simply change in one spot. What actually occurs-as described in Item #3 above- is that the thickness change (usually somewhat abrupt-as a grind or a machined area) creates substantial flux-leakage in the localized area. This causes the EMI Wall loss sensor in that area to respond differently than the other wall loss sensors - see **FIG No. 7**. This could be considered an undesirable aspect of EMI Wall loss measurement as it can interfere with the true flux-density reading and it is redundant as the EMI Flaw detection system is already detecting and locating localized areas of flux-leakage in the transverse system. Example - a 10% or 20% wall loss grind that occurs over a 4" or 6" area will usually give a much higher indication than the same wall loss whereas the grind is contoured out over a much larger area and the flux leakage from the grind is less drastic.



Misconception/Myth #3 - More EMI Wall sensors or channels are better or give better coverage. Because the flux-density changes throughout the inside of the coil when the cross-sectional area or permeability changes, a sufficient wall loss in a piece of pipe placed at 12:00 in the coil will change the flux-density at the 6:00 position as well as positions 3:00, 9:00, 9:30, 6:45, etc. Technically speaking, for monitoring EMI Wall loss and FLUX DENSITY, only 1 sensor may be needed.

SUMMARY

EMI Wall systems detect magnetic anomalies. Prove-up or further evaluation is critical to the integrity of the inspection.

A) A 20% grind in pipe will usually produce a larger indication than a through-drill hole, even though the through-drill hole is a 100% wall loss.
B) Two 20% deep rod cuts in tubing may look like one 40% deep rod cut.
C) It is easier to detect a 5% deep grind in small diameter casing than a 10% deep grind in large diameter casing (with the same wall thickness) - because the ratio of wall loss to cross sectional area is higher in the small diameter tube.
D) A joint of drill pipe that spins in one area and creates a hard spot on the pipe will give a thinner indication because of the permeability difference.

There is a tremendous potential for development in the EMI field as well as the ultrasonic field as far as pipe inspection equipment potential - just look at what is being done in the medical industry with magnetics and ultrasonics. My report is based on the current industry standards and the equipment that I have been involved with to date.

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