CSI Tech Brief

CARBON STEEL INSPECTION, INC
VERSA INTEGRITY GROUP

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What's It All About?

We at Carbon Steel Inspection are often asked to provide a general description or background information of our Remote Field Technology, which we have developed and licensed to Zetec, Inc. There are many different manufacturers of the Remote Field Technique, over ten as of a couple of years ago. This Tech Brief only addresses our technology from our perspective and bias and does not imply the capabilities or limitations of other technologies.

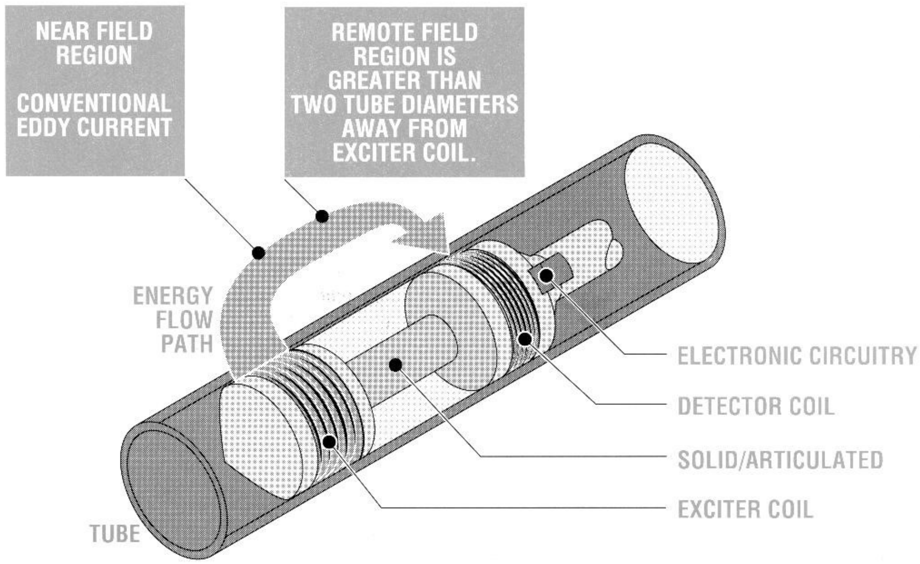

Figure 1

DEFINITION

The Remote Field Technique is an electromagnetic examination which utilizes the through transmission effect to produce a resultant field that is affected by anomalies and is measured a few or more tube diameters away from the AC excitation source without any tube magnetization or saturation

RFT GENERAL DESCRIPTION

The remote field phenomenon is an electromagnetic testing technique used primarily for the in-service, baseline, or QC inspection of ferromagnetic tubing/pipe.

This inspection consists of a full length examination performed from the inside of the tube with equal inner and outer surface discontinuity detection and sizing.

An alternating current is applied to an excitation coil which generates a strong electromagnetic field that propagates out of and extends away from the exciter along the tube length. The field then reenters the tube wall axially from the exciter. This is referred to as through transmission, a term and effect commonly used in the Ultrasound Testing Method. The field has three distinct areas that are known as the Near Field Zone, Transition Zone and the Remote Field Zone. During the field's propagation, the field intensity decays exponentially in the near field zone and linearly in the remote field zone.

The resultant Remote Field Zone's strength decreases to 1/1,000,000th the strength of the near zone, or as microvolts of induced voltage.

The induced voltage is measured through the use of a detector coil, bobbin or pancake, that is placed in the remote field zone providing for a volumetric inspection with equal sensitivity to ID and OD anomalies of the tube. The sensor coils pick up the disturbance of the field due to the presence of an anomaly caused by corrosion, stress, foreign object or mechanical vibration. Inherent permeability variations (PV) are easily discerned from tube degradation signals.

In accordance with ASME Section V, Article 8 guidelines, the technology has the ability to display the resultant signal in a vector (X-Y) format. This form of two dimensional signal display allows the data analyst to use pattern recognition for characterizing signals. This is a distinct advantage over single dimensional (amplitude only) analysis techniques.

Typically, the analysis parameters are established where the phase or angular relationship of the signal is measured relative to the X-axis, in degrees, which equates to flaw depth. The amplitude in Volts or size of the signal relates proportionally to the volume loss in a material. However, the phase of the signal is volumetrically dependent. The ID and OD defect phase planes are equivalent and the distinction between the two is a matter of signal formation (clockwise versus counter-clockwise). Most often a signal to PV or noise ratio greater than five is required to provide sufficient information to discern between ID and OD orientation. For us, this discrimination is only possible in the laboratory and we claim no distinction between ID or OD origination in the field.

FIELD ADJUSTMENT

The tube exit signal, baseline and tube support\ baffle establish certain reference points for nominal conditions and is used to determine the defect phase envelope. The instrument parameters can then be adjusted in the field to achieve a certain resolution. Typically, the baffle or tube support response is normalized with the out-of-tube signal to determine the appropriate frequency.

RESOLUTION

Resolution is the phase separation between flaws of varying depths and will vary with excitation frequency. If lower operating frequencies are used, an increase in the depth of penetration results in an increase in magnitude of the resultant field which causes a larger signal response with reduced resolution. Conversely, higher frequencies have less depth of penetration reducing the magnitude of the resultant field but an increased flux density provides for greater resolution. Therefore a multifrequency tester provides greater capability for a broad range of tubing applications.

SENSITIVITY

Sensitivity is dependent on the type of material, grade, dimensions, wall thickness, residual stresses, operating conditions such as aging -- ambient temperature -- tube cleanliness -- and location. The last item affects the sensitivity due to the fact that as the field propagates outside of the tube wall, external material can short or shunt the field that prevents the field from reaching the pickup coils. Examples of shunting material would include tube support plates, tube sheets and welded attachments. Other examples, including tubes external to or encircling the tested tube and OD enhancements such as Aluminum fins, have a limiting effect on the field strength.

TRAVERSE SPEEDS

Probe traverse speeds are dependent upon the data sampling rate which can never be more than the lowest operating frequency. Selection of operating frequencies will be determined by the anticipated volumetric loss of anomalies. Typically, when examining a tube such as 3/4 x 0.049 wall SA 179 grade carbon steel, for anticipated ASME volume pits, at operating frequencies of 1 to 2 KHz the traverse speeds of 18 to 24 inches per second are attained. When inspecting 1.0" x .120" wall SA 214 carbon steel, at operating frequencies of 150 Hz pull speeds on the order of 4 to 6 inches per second are more realistic. Larger volume flaws will enable faster pull speeds.

DESIGN

RFT probe design is affected by many considerations and variables. Some of the have been described previously. Probes are designed for specific applications and may or may not be suitable for testing other materials. The probe length can vary depending on design and is typically at least 4 to 5 times to OD of the tube/pipe to be inspected. This will limit the axial extent of the inspection for a U-Bend tube or necessitate the partial inspection from the opposite end when inspecting a straight tube as shown in Figure 1. Consequently, dual exciter probes are designed to achieve sensitivity on both sides of the baffle plate and to both sides of the tubesheet on a straight section tube. We only use dual exciter probes in all shell and tube heat exchangers. Flexible probes are designed to overcome accessibility limitations and traverse bends.

By: Gary Kroner