Designation: E 309 – 95 (Reapproved 2001)

Standard Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[1]

This standard is issued under the fixed designation E 309; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice[2] covers a procedure for applying the eddy-current method to detect discontinuities in ferromagnetic pipe and tubing (Note 1) where the article being examined is rendered substantially non-magnetic by the application of a concentrated, strong magnetic field in the region adjacent to the examining coil.

NOTE 1—For convenience, the term tube or tubular product will hereafter be used to refer to both pipe and tubing.

1.2 The procedure is specifically applicable to eddy-current examination methods using an encircling-coil assembly. However, eddy-current techniques that employ either fixed or rotating probe-coil assemblies may be used to either enhance discontinuity sensitivity on the large diameter tubular products or to maximize the response received from a particular type of discontinuity.

1.3 This practice is intended for use on tubular products having outside diameters from approximately ¼ to 10 in. (6.35 to 254.0 mm). These techniques have been used for smaller and larger sizes however, and may be specified upon contractual agreement between the purchaser and the supplier.

2. Referenced Documents

2.1 *ASTM Standards:*

E 543 Practice for Agencies Performing Nondestructive Testing[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[4]

2.3 *Military Standard:*

MIL-STD-410E Nondestructive Testing Personnel Qualification and Certification[5]

3. Terminology

3.1 *General*—Standard terminology relating to electromagnetic examination may be found in Terminology E 1316, Section C, "Electromagnetic Testing."

4. Summary of Practice

4.1 The examination is conducted using one of two general techniques shown in Fig. 1.

4.1.1 One technique employs one or more exciter and sensor coils that encircle the tube and through which the tubular product to be examined is passed. Some circuit configurations employ one or more coils that concurrently function as both exciters and sensors. Alternating current passes through the exciting coil which, by reason of its proximity, induces corresponding currents (eddy currents) to flow in the tubular product. The sensor coil detects the resultant electromagnetic flux related to these currents. The presence of discontinuities in the tubular product will alter the normal flow of currents and this change is detected by the sensor. The encircling-coil technique is capable of examining the entire circumference of a tubular product.

4.1.2 Another technique employs a probe coil with one or more sensors that are in close proximity to the surface of the tubular product to be examined. Since the probe is generally small and does not encircle the article being examined, it examines only a limited area in the vicinity of the probe. This technique is frequently used for examination of welded tubular products in which only the weld is examined by scanning along the weld zone.

4.1.3 The magnetic permeability of ferromagnetic materials severely limits the depth of penetration of induced eddy currents. Furthermore, the permeability variations inherent in ferromagnetic tubular products often cause anomalous test

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing, and is the direct responsibility of Subcommittee E07.07 on Electromagnetic Methods.

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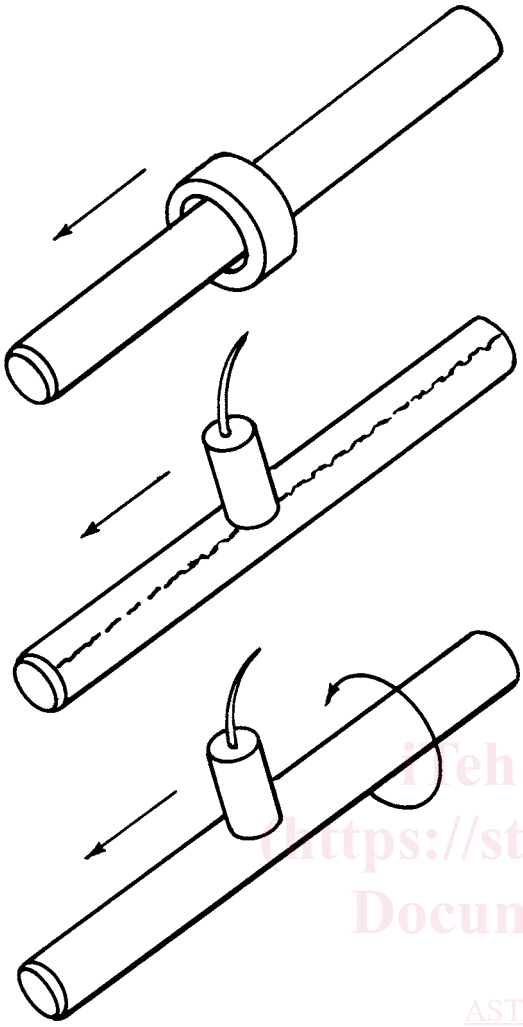
[2] For ASME Boiler and Pressure Vessel Code applications see related Recommended Practice SE 309 in Section V of that Code.

[3] *Annual Book of ASTM Standards*, Vol 03.03.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.



(*a*) Encircling Coil.

(*b*) Probe Coil—longitudinal scanning of weld seam only.

(*c*) Probe Coil—scanning along a spiral path.

FIG. 1 Encircling-Coil and Probe-Coil Techniques for Electromagnetic Testing of Tubular Products

results. A useful solution to this problem involves the application of a strong external magnetic field in the region of the examining coil or probe. This technique, known as magnetic saturation, is applied to a magnetic material, such as a steel tube, to suppress the magnetic characteristics of permeability, hysteresis, etc., so that the material under examination is effectively rendered nonmagnetic. When achieved, this condition allows an eddy-current system to measure and detect electrical resistivity and geometrical variations (including defects) independent of concurrent variations in magnetic properties.

4.1.4 Changes in electromagnetic response caused by the presence of discontinuities are detected by the sensor, amplified, and modified in order to actuate audio or visual indicating devices, or both, a mechanical marker, or a signal-recording device, or a combination of these. Signals can be caused by outer surface, inner surface, or subsurface discontinuities if the eddy-current frequency provides sufficient depth of penetration (see 11.1). The eddy-current method is sensitive to metallurgical variations that occur as a result of processing, thus all received indications are not necessarily indicative of defective tubing.

5. Significance and Use

5.1 The purpose of this practice is to outline a procedure for the detection and location of discontinuities such as pits, voids, inclusions, cracks, or abrupt dimensional variations in ferromagnetic tubing using the electromagnetic (eddy-current) method. Furthermore, the relative severity of a discontinuity may be indicated, and a rejection level may be set with respect to the magnitude of the indication.

5.2 The response from natural discontinuities can be significantly different than that from artificial discontinuities such as drilled holes or notches. For this reason, sufficient work should be done to establish the sensitivity level and set-up required to detect natural discontinuities of consequence to the end use of the product.