Designation: E 1033 – 98 (Reapproved 2004)$^{\epsilon 1}$

Standard Practice for Electromagnetic (Eddy-Current) Examination of Type F-Continuously Welded (CW) Ferromagnetic Pipe and Tubing Above the Curie Temperature[1]

This standard is issued under the fixed designation E 1033; 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.

ϵ[1] NOTE—Referenced documents and editorial changes were made in January 2004.

1. Scope

1.1 This practice covers a procedure for in-line, eddy-current examination of continuously welded (CW) ferromagnetic pipe and tubing at temperatures above the Curie temperature (approximately 1400°F [760°C], where the pipe is substantially nonmagnetic or austenitic.

1.2 This practice is intended for use on tubular products having nominal diameters of ½ in. [12.7 mm] to 4 in. [101.6 mm]. These techniques may be used for larger- or smaller-diameter pipe and tubing as specified by the using parties.

1.3 This practice is specifically applicable to eddy-current examination using encircling coils, or probe coils.

1.4 This practice does not establish acceptance criteria. They must be established by the using parties.

1.5 The values stated in inch-pound units are to be regarded as standard. The SI units in brackets may be approximate.

1.6 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 543 Practice for Agencies Performing Nondestructive Testing

E 1316 Terminology for Nondestructive Examinations

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[3]

ANSI/ASNT-CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[3]

NAS-410 NAS Certification and Qualification of Nondestructive Personnel (Quality Assurance Committee)[4]

3. Terminology

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

4. Summary of Practice

4.1 In-line, automatic, eddy-current examination of CW pipe utilizes probes or encircling coils, or both, mounted in the pass line to monitor the quality of pipe during production at temperatures ranging from 1600 to 2200°F [870 to 1204°C].

4.2 Eddy-current instrumentation provides timely and useful information regarding the acceptability of CW pipe for quality control purposes as well as for early warning that unacceptable pipe is being produced.

5. Significance and Use

5.1 The purpose of this practice is to outline a procedure for the in-line eddy-current examination of hot CW pipe for the detection of major imperfections and repetitive discontinuities.

5.2 A major advantage of in-line eddy-current examination of ferromagnetic CW pipe above the Curie temperature lies in the enhanced signal-to-noise ratio and depth of penetration obtained without the use of magnetic saturation.

5.3 The eddy-current method is capable of detecting and locating weld imperfections commonly referred to as open welds, cave welds, black spots (weld inclusions), and partial welds (incomplete penetration). In addition, it will detect pipe-wall imperfections such as slivers, laps, and ring welds (end welds).

[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 referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, PO Box 28518, Columbus, OH 43228–0518.

[4] Available from Aerospace Industries Association of America, Inc., 1250 Eye Street, N.W., Washington, DC 20005.

5.4 The relative severity of the imperfections may be indicated by eddy-current signal amplitude or phase, or both. An alarm level may be selected that utilizes signal amplitude or phase, or both, for automatic recording or marking, or both.

5.5 Because the responses from natural discontinuities may vary significantly from those from artificial discontinuities, care must be exercised in establishing test sensitivity and acceptance criteria.

6. Basis of Application

6.1 The following criteria may be specified in the purchase specification, contractual agreement, or elsewhere, and may require agreement between the purchaser and the supplier.

6.1.1 The diameter, wall-thickness, and temperature of the pipe being examined.

6.1.2 The extent of the examination.

6.1.3 The time of examination: the point or points in the manufacturing process where the pipe will be examined, and its throughput speed.

6.1.4 *Test Standardization*:

6.1.4.1 The size (length, diameter, and wall) and composition of the reference standard if applicable.

6.1.4.2 The time between calibration checks.

6.1.5 The disposition of material with indications.

6.1.6 The reporting of test results.

6.1.7 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, MIL-STD-410E, NAS-410, ASNT-ACCP, or a similar document and certified by the certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

NOTE 1—MIL-STD-410 is canceled and has been replaced with NAS-410, however, it may be used with agreement between contracting parties.

6.1.8 If specified in the contractual agreement, NDT agencies shall be qualified and evaluated in accordance with Practice E 543. The applicable edition of Practice E 543 shall be specified in the contractual agreement.

7. Interferences

7.1 There are some manufacturing processes that produce pipe with surface conditions that could interfere with or obscure signals related to typical pipe imperfections.

7.2 Mechanical vibrations, speed variations, and temperature changes can have an affect on test sensitivities.

8. Apparatus

8.1 The transducer assembly, whether encircling or probe coils, consists of one or more electrical coils, cooling apparatus that is adequate to maintain the proper coil-operating temperature and prevent thermal damage, and positioning mechanisms for adjusting and maintaining a constant spacing between the coil and the pipe surface. Some assemblies may include mechanical guides to prevent physical damage to the transducer by contact with the product.

8.1.1 The types and sizes of transducers employed are determined to a large degree by the coverage and resolution required. Through precise transducer positioning, the geometries required for effective pipe inspection can be maintained.

8.1.2 The eddy-current transducers are cooled to maintain proper operating temperatures for test stability, and to avoid thermal damage to the windings or the associated fixturing, or both.

8.1.3 The optimum response to the variables of interest (see 5.3) can be obtained through the selection of the proper instrumentation, transducer design, and operating frequency. Through signal processing, responses to variables of interest can be increased while those from such sources as scale patches, cold spots, and mechanical vibration can be suppressed.

8.1.4 Usually, the transducer assembly is placed at a location where product speed is constant and vibration is minimal.

8.2 The eddy-current instrumentation should be capable of energizing transducers with alternating currents of selected and stable frequencies and energy levels, and of sensing the changes in eddy-current flow arising from pipe imperfections.

8.2.1 Eddy-current responses may be displayed on a cathode-ray tube, indicated by a meter, digital display, strip-chart recorder, or other applicable methods.

8.2.2 Automatic alarm and marking features may be included and can provide automatic classification at production-line speeds.

9. Adjustment and Standardization of Apparatus

9.1 The method of manufacture of CW pipe precludes the use of a physical reference standard for in-line system standardization as is the norm for most eddy-current examinations. The continuity of product runs and the high-line speeds (up to 3000 ft/min or 15.2 M/s) requires the use of alternative calibration methods.

9.2 The industry-accepted methods for system standardization and sensitivity adjustment include either electronically generated signals to simulate responses to reference notches, or the use of eddy-current noise levels to obtain repeatable sensitivities.

9.2.1 Electronic signals that simulate those obtained from actual imperfections during eddy-current examination can be induced into the transducer and the instrumentation adjusted to the appropriate response levels.

9.2.2 The eddy-current noise level is that actually generated as the pipe passes through or by the transducer. Instrument controls may be adjusted so that the material-generated noise is some predetermined fraction of full-scale response. Through experience, sensitivities suitable for detecting imperfections of interest can be obtained. It must be clearly established that the noise level is material-generated and not from the instrumentation.

9.2.3 Verification of the sensitivity levels obtained through either the electronic-signal or the system-noise may be established through other nondestructive or mechanical examination methods, or both.

9.3 If standardization with conventional reference standards is applicable, off-line standardization may be performed using pipe samples of appropriate sizes made from austenitic stainless steel.

9.3.1 Refer to Practice E 309, paragraph 7.6 and Section 10, for reference standard fabrication and Section 9 for standardization procedures.

10. Operating Procedure

10.1 Standardize the system in a manner similar to that given in Section 9 at the beginning of each turn and when changing sizes.

10.2 Pipes and tubes to be examined are passed through the examination station with the apparatus adjusted in accordance with Section 9.

10.3 Any piece showing a discontinuity indication equal to or greater than an established rejection level shall be automatically marked or otherwise identified as having a potentially rejectable discontinuity.

10.4 Make no equipment adjustments other than at standardization time.

11. Keywords

11.1 curie temperature; eddy-current; electromagnetic; NDT; nondestructive testing