Designation: E1312 – 18

Standard Practice for Electromagnetic (Eddy Current) Examination of Ferromagnetic Cylindrical Bar Product Above the Curie Temperature[1]

1. Scope*

1.1 This practice covers procedures for eddy current examination of hot ferromagnetic bars above the Curie temperature where the product is essentially nonmagnetic, but below 2100 °F (1149 °C).

1.2 This practice is intended for use on bar products having diameters of ½ in. (12.7 mm) to 8 in. (203 mm) at linear throughput speeds up to 24 000 ft/min (122 m/sec). Larger or smaller diameters may be examined by agreement between the using parties.

1.3 The purpose of this practice is to provide a procedure for in-line eddy current examination of bars during processing for the detection of major or gross surface discontinuities.

1.3.1 The types of discontinuities capable of being detected are commonly referred to as: slivers, laps, seams, roll-ins (scale, dross, and so forth), and mechanical damage such as scratches, scores, or indentations.

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

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this practice to establish appropriate safety, health, environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E543 Specification for Agencies Performing Nondestructive Testing

E1316 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 Standard for Qualification and Certification of NDT Personnel[3]

2.3 *AIA Standard:*

NAS 410 Certification and Qualification of Nondestructive Testing Personnel[4]

2.4 *International Standards:*[5]

ISO 9712 Non-Destructive Testing—Qualification and Certification of NDT Personnel

3. Terminology

3.1 Standard terminology relating to electromagnetic testing may be found in Terminology E1316, Section C: Electromagnetic Testing.

4. Summary of Practice

4.1 *Principle*—The major advantage of examining ferromagnetic bar product above the Curie temperature with eddy currents is the enhanced signal-to-noise ratio obtained without the need for magnetic saturation.

[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 Method.

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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 (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

***A Summary of Changes section appears at the end of this standard**

4.2 *Sensors*—This examination may be performed with various types or designs of encircling coils or with probe coils that are fixed or rotating.

4.2.1 One or more exciter or sensor coils is used to encircle the bar through which the product to be examined is passed. When the hot bar is in close proximity to the sensing and exciting coils, eddy currents are induced in the hot product by an alternating current. The sensing coil detects the electromagnetic flux related to these currents. Changes or disruptions in the normal flux pattern indicate the presence of discontinuities. This technique is capable of examining the entire circumference without contacting the product.

4.2.2 The surface can also be examined with probe coils having one or more exciters and sensors which are spaced in close proximity to the product surface. The probe is usually small and does not encircle the product, making it necessary to rotate either the probes or the product to obtain 100 % coverage of the circumference. This is essentially a contact technique because the coil is fixtured in a device that rides on the circumference to maintain a fixed distance between the coil and product surface.

4.2.3 Discontinuities cause either a change in phase or signal amplitude when detected by the sensing coil. These signals are amplified and processed to activate marking or recording devices, or both. Relative severity of the imperfection can be indicated by the signal amplitude generated by the flux change or the degree of change in phase.

4.2.4 Caution must be exercised in establishing reference standards because flux changes caused by natural discontinuities might differ significantly from those generated by artificial discontinuities.

5. Significance and Use

5.1 The purpose of this practice is to describe a procedure for in-line-eddy-current examination of hot cylindrical bars in the range of diameters listed in 1.2 for large and repetitive discontinuities that may form during processing.

5.2 The discontinuities in bar product capable of being detected by the electromagnetic method are listed in 1.3.1. The method is capable of detecting surface and some subsurface discontinuities that are typically in the order of 0.030 in. (0.75 mm) and deeper, but some shallower discontinuities might also be found.

5.3 Discontinuities that are narrow and deep, but short in length, are readily detectable by both probe and encircling coils because they cause abrupt flux changes. Surface and subsurface discontinuities (if the electromagnetic frequency provides sufficient effective depth of penetration) can be detected by this method.

5.3.1 Discontinuities such as scratches or seams that are continuous and uniform for the full length of cut length bars or extend for extensive linear distances in coiled product may not always be detected when encircling coils are used. These are more detectable with probe coils by intercepting the discontinuity in their rotation around the circumference.

5.3.2 The orientation and type of coil are important parameters in coil design because they influence the detectability of discontinuities.

5.4 The eddy current method is sensitive to metallurgical variations that occur as a result of processing, thus all received signals above the alarm level are not necessarily indicative of defective product.

6. Basis of Application

6.1 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally recognized nondestructive testing (NDT) personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, ISO-9712, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6.2 *Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

6.3 *Acceptance Criteria*—Since acceptance criteria are not specified in this practice, they shall be specified in the contractual agreement.

7. Apparatus

7.1 *Electronic Apparatus,* should be capable of energizing the test coils or probes with alternating current at selectable frequencies from 400 Hz to 100 kHz. Either manual or remotely operated switches can be used for frequency selection. The equipment should include a detector display (CRT, meters), phase discriminator, filters, modulators, recorders, and alarming/marking devices required for particular applications.

7.2 *Sensors,* whether probe or encircling coils, should operate through a frequency range from 400 Hz to 100 kHz.

7.2.1 The sensor windings must be cooled (such as water jackets) to control the sensor operating temperature and prevent thermal damage to the sensors.

7.2.2 Magnetic or electrostatic shields might be necessary to suppress extraneous electrical transient noise. Electrostatic shields usually float above ground at the sensor and are connected to a cable and then to the preamplifier shield.

7.2.3 Constant spacing, ranging from $1/16$ in. (1.6 mm) to $1/4$ in. (6.4 mm) between the sensors and product surface is obtained with positioning mechanisms usually equipped with product guiding devices to prevent mechanical damage to the sensors.

7.3 *Transport Mechanism*—A conveyor or other type of mechanical device should be employed to pass the product through or past the sensors. It should operate at production (or system) speeds with a minimum vibration of the sensors or product, and should maintain alignment of the sensors and product within the specified tolerances. Some systems may require the transport to rotate either the bar, the sensors, or both.

7.3.1 The mechanical tolerances for restraining the longitudinal centerline of the product relative to the coils are critical. Non-uniform sensitivity, the generation of erroneous signals or