Designation: E 566 – 99 (Reapproved 2004)$^{\epsilon 1}$

Standard Practice for Electromagnetic (Eddy-Current) Sorting of Ferrous Metals[1]

This standard is issued under the fixed designation E 566; 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—Editorial changes were made to provide consistent terminology in May 2004.

1. Scope

1.1 This practice covers the procedure for sorting ferrous metals using the electromagnetic (eddy-current) method. The procedure relates to instruments using absolute or comparator-type coils for distinguishing variations in mass, shape, conductivity, permeability, and other variables such as hardness and alloy that affect the electromagnetic or magnetic properties of the material. The selection of specimens to determine sorting feasibility and to establish standards is also included.[2]

1.2 *This standard 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 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:* [3]

E 105 Practice for Probability Sampling of Materials

E 122 Practice for Calculating Sample Size to Estimate, with a Specified Tolerable Error, the Average for Characteristic for a Lot or Process

E 543 Practice for Agencies Performing Nondestructive Testing

E 1316 Terminology for Nondestructive Examinations

2.2 *ASNT Documents:*

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

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

2.3 *AIA Standard:*

NAS-410 Qualification and Certification of Nondestructive Testing Personnel [5]

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 The two techniques that are primarily used in electromagnetic sorting employ the absolute (single-) and comparative (two-) coil methods. The decision of whether to use single-coil or two-coil operation is usually determined by empirical data. In the absolute-coil method, the equipment is standardized by placing standards of known properties in the test coil. The value of the tested parameter (for instance, hardness, alloy, or heat treatment) is read on the scale of an indicator. In the comparative-coil method, the test specimen is compared with a reference specimen and the indication tells whether the test specimen is within or outside of the required limits.

4.1.1 *Absolute Coil Method*—A specimen of known classification is inserted in the test coil, and the controls of the instrument are adjusted to obtain an indication. The method is then continued by inserting the test specimens to be sorted into the test coil, and observing the instrument indication.

4.1.2 *Comparative Coil Method*—Known reference specimens representing the minimum or maximum limits of acceptance, or both, are inserted in the reference coil and test coil. The instrument controls are adjusted for appropriate indications. The method is then continued by inserting the test specimens to be sorted in the test coil, leaving a known reference in the reference coil, and observing the instrument indication.

4.2 The range of instrument indication must be so adjusted in the initial step that the anticipated deviations will be recognized within the range of readout according to whether two- or three-way sorts are to be accomplished.

4.3 Both absolute and comparative methods require comparing the test specimens with the reference specimen(s). Two

[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] General information can be found in the *Nondestructive Testing Handbook,* (Second Edition), Vol IV: Electromagnetic Testing, Society for Nondestructive Testing, 1986.

[3] 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.

[4] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

or more specimens representing the limits of acceptance may be required. In the absolute method the electrical reference is generated by a test specimen. In the comparative method any electromagnetic condition that is not common to the test specimen and the reference specimen will produce an imbalance in the system. The comparative method usually is more stable, as it normally suppresses noise.

4.4 The testing process may consist of manual insertion of one specimen after another into the test coil, or an automated feeding and classifying mechanism may be employed. In automated setups, it is sometimes necessary to stop each specimen momentarily in the test coil while the reading is being taken, especially if low test frequencies are employed.

5. Significance and Use

5.1 Absolute and comparative methods provide a means for sorting large quantities of ferrous parts of stock with regard to composition, condition, structure, or processing, or a combination thereof.

5.2 The comparative or two-coil method is used when high-sensitivity testing is required. The advantage of this method is that it almost completely suppresses all internal or external disturbances such as temperature variations or stray magnetic fields. The two-coil method is normally used when harmonic evaluation is employed for sorting.

5.3 The ability to accomplish satisfactorily these types of separations is dependent upon the relation of the magnetic characteristics of the ferromagnetic parts to their physical condition.

5.4 These methods may be used for high-speed sorting in a fully automated setup where the speed of testing may approach ten specimens per second depending on their size and shape.

5.5 The success of sorting ferromagnetic material depends mainly on the proper selection of magnetic field strength and frequency of signal in the test coil, fill factor, and variables present in the sample.

5.6 The degree of accuracy of a sort will be affected greatly by the coupling between the test coil field and the test specimen and the accuracy with which the specimen is held in the test coil field during the measuring period.

5.7 When high currents are used in the test coil, a means should be provided to maintain a constant temperature of the reference specimen in order to minimize measurement drift.

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, 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 Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E 543. The applicable edition of Practice E 543 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. Interferences

7.1 The specific influence of the following variables must be considered for proper interpretation of the results obtained:

7.1.1 The correlation shall be established so that magnetic or electrical properties, or both, of various groups do not overlap and are well defined in the standardization procedure used.

7.1.2 In sorting magnetic materials, a magnetic field strength and test frequency must be used that will result in a well-defined separation of variables being tested.

7.1.3 When examining magnetic materials at low field strength, any influence from the previous magnetic history of the test specimen (residual magnetism) shall be negated by demagnetization of the specimen if it restricts the electromagnetic sort.

7.1.4 The temperature of the reference specimen and test specimen shall be controlled within limits that will permit a well-defined range of conductivity or permeability, or both, for which the correlation of the group or groups is valid. Cooling of the reference specimens when high field strengths are used or allowing test specimens to cool or heat to an established ambient range, or both, may be required.

7.1.5 The geometry and mass of the reference standard and test specimen shall be controlled within limits that will permit sorting.

7.1.6 *Speed Effects*—See 4.4.

8. Apparatus

8.1 *Electronic Apparatus*—The electronic apparatus shall be capable of energizing the test coils with alternating currents of suitable frequencies and power levels and shall be capable of sensing the changes in the electromagnetic response of the test coils. Equipment may include any suitable signal-processing devices (phase discriminator, filter circuits, etc.) and the output may be displayed by meter, scope, recorder, signaling devices or any suitable combination required for the particular application.

8.2 *Test Coils* may be of the encircling or probe-coil type and shall be capable of inducing an electromagnetic field in the test specimen and reference specimen and sensing changes in the electric and magnetic characteristics of the test specimen.

8.2.1 When selecting the test coil, the objective should be to obtain a coil fill factor as large as possible. This means that the inside of the test coil should be filled by the test specimen as much as possible. This is of primary importance for tests requiring high sensitivity.

8.2.2 For complicated test specimen shapes, a corresponding insert shall be provided to ensure that each specimen can be placed in the same position within the test coil. These inserts, as well as any other accessories, should consist of nonferromagnetic, electrically nonconductive material.

8.3 *Mechanical Handling Apparatus*—A mechanical device for feeding and sorting the test specimens may be used to automate the particular application.