INTERNATIONAL

Designation: ~~E566 – 14~~ E566 – 19

Standard Practice for Electromagnetic (Eddy ~~Current)~~ Current/Magnetic Induction) Sorting of Ferrous Metals[1]

This standard is issued under the fixed designation E566; 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.

1. Scope*

1.1 This practice covers the procedure for sorting ferrous metals using the electromagnetic (eddy ~~current)~~ current/magnetic induction) 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 reference standards 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *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:*[3]

E105 Practice for Probability Sampling of Materials

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ASNT Documents:*[4]

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

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

2.3 *AIA Standard:*[5]

NAS-410 Qualification and Certification of Nondestructive Testing Personnel

2.4 *ISO Standard:*[6]

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

3. Terminology

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

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[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] 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 American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

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

[6] 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. Summary of Practice

4.1 The techniques that are primarily used in electromagnetic sorting employ the absolute (single-) ~~and~~or 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~~ could be read on the scale of an ~~indicator.~~ indicator or any other display. In the comparative-coil method, the test specimen is compared with a reference standard and the indication tells whether the test specimen is within or outside of the required limits. These limits are defined by the user based on the application and requirement.

4.1.1 *Absolute Coil Method*—A reference standard 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*—Reference standards 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 reference standard 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 standards. Two or more reference standards representing the limits of acceptance may be required. In the absolute method the electrical reference is generated by a reference standard. In the comparative method any electromagnetic condition that is not common to the test specimen and the reference standard 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.~~fields, provided both the coils and both the reference parts are exposed to the same conditions which are not of relevance.

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. Testing with harmonics can, to a large extent, reduce the sensitivity to accuracy of location.

5.7 When high currents are used in the test coil, a means should be provided to maintain a constant temperature of the reference standard 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, 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~~Specification E543. The applicable edition of ~~Practice~~Specification 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. 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 examination frequency must be used that will result in a well-defined separation of variables being examined.

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 standard 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 standards 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 standard 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 examinations 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,~~non-ferromagnetic, 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.

9. Sampling

9.1 Sampling (see Practices E105 and E122) is a method to obtain assurance that materials are of satisfactory quality. Instead of 100 % inspection, a portion of the material is examined to show evidence of the quality of the whole. There are two important needs for this approach: first, in the final inspection or examinations made to ensure that products delivered are in conformance with specification requirements; second, to control parts and assemblies while they are being processed. Statistical acceptance sampling tables and statistical process-control sampling tables have been developed to meet these needs.

9.2 Acceptance sampling may be conducted on an accept/reject (or attributes) basis, that is, determining whether or not the units of the sample meet the specification. Examination of the samples may also be conducted on a measurements (or variables) basis, that is, determining actual readings on the units in the sample. The majority of acceptance sampling is carried out on a sampling by the attributes basis and the usual acceptance sampling table is designed for accept/reject criteria.

9.3 Process control sampling may be conducted on material during the course of production to prevent large quantities of defective parts being found in the acceptance tests. Many parts and materials are subjected to several successive machining or processing operations before they become finished units. Parts can be most effectively controlled during production by examining small samples of these parts at regularly scheduled intervals. The object of this process check is to provide a continuous picture of the quality of parts being produced. This helps prevent production of defective parts by stopping and correcting the problem as soon as it begins to appear in the manufacturing process and thereby keeping the process in control. Sampling may be by attributes or by variable and process control sampling tables. The measurements (variables) control chart is by far the most effective process control technique.

9.4 Statistical sampling tables have four definite features: (*1*) specifications of sampling data, that is, the size of the samples to be selected, the conditions under which the samples are to be selected, and the conditions under which the lot will be accepted or rejected; (*2*) protection afforded, that is, the element of risk that the sampling schedules in a given table will reject good lots or