Designation: E215 – 22

Standard Practice for Standardizing Equipment and Electromagnetic Examination of Seamless Aluminum-Alloy Tube[1]

This standard is issued under the fixed designation E215; 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 standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice[2] is for standardizing eddy current equipment employed in the examination of seamless aluminum-alloy tube. Artificial discontinuities consisting of flat-bottomed or through holes, or both, are employed as the means of standardizing the eddy current system. General requirements for eddy current examination procedures are included.

1.2 Procedures for fabrication of reference standards are given in X1.1 and X2.1.

1.3 This practice is intended for the examination of tubular products having nominal diameters up to 4 in. (101.6 mm) and wall thicknesses up to the standard depth of penetration (SDP) of eddy currents for the particular alloy (conductivity) being examined and the examination frequency being used.

NOTE 1—This practice may also be used for larger diameters or heavier walls up to the effective depth of penetration (EDP) of eddy currents as long as adequate resolution is obtained and as specified by the using party or parties.

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

1.5 *Units*—The values stated in inch-pound units are to be regarded as the 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 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, health, and 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:*[3]

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *Federal Standard:*[4]

Fed Std. No. 245D Tolerance for Aluminum Alloy and Magnesium Alloy Wrought Products

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology E1316.

4. Significance and Use

4.1 The examination is performed by passing the tube lengthwise through or near an eddy current sensor energized with alternating current of one or more frequencies. The electrical impedance of the eddy current sensor is modified by the proximity of the tube. The extent of this modification is determined by the distance between the eddy current sensor and the tube, the dimensions, and electrical conductivity of the tube. The presence of metallurgical or mechanical discontinuities in the tube will alter the apparent impedance of the eddy current sensor. During passage of the tube, the changes in eddy current sensor characteristics caused by localized differences in the tube produce electrical signals which are amplified and modified to actuate either an audio or visual signaling device or a mechanical marker to indicate the position of discontinuities in the tube length. Signals can be produced by discontinuities

[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.

Current edition approved June 1, 2022. Published July 2022. Originally approved in 1963. Last previous edition approved in 2016 as E215 – 16. DOI: 10.1520/E0215-22.

[2] For ASME Boiler and Pressure Vessel Code applications, see related Practice SE-215 in the Code.

[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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

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

located either on the external or internal surface of the tube or by discontinuities totally contained within the tube wall.

4.2 The depth of penetration of eddy currents in the tube wall is influenced by the conductivity (alloy) of the material being examined and the excitation frequency employed. As defined by the standard depth of penetration equation, the eddy current penetration depth is inversely related to conductivity and excitation frequency (Note 2). Beyond one standard depth of penetration (SDP), the capacity to detect discontinuities by eddy currents is reduced. Electromagnetic examination of seamless aluminum alloy tube is most effective when the wall thickness does not exceed the SDP or in heavier tube walls when discontinuities of interest are within one SDP. The limit for detecting metallurgical or mechanical discontinuities by way of conventional eddy current sensors is generally accepted to be approximately three times the SDP point and is referred to as the effective depth of penetration (EDP).

NOTE 2—The standard depth of penetration is defined by the following equations:

$$\text{SDP} = 503.3\sqrt{\frac{1}{f\sigma}}$$

where:

SDP = one standard depth of penetration, m,
f = frequency, Hz (cycles per second), and
σ = conductivity, Siemens/metre.

or:

$$\text{SDP} = 26\sqrt{\frac{1}{f\sigma}}$$

where:

SDP = one standard depth of penetration, in.,
f = frequency in Hz (cycles per second), and
σ = conductivity, % IACS.

5. Basis of Application

5.1 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 and certified by the certifying agency as applicable. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

5.2 If specified in the contractual agreement, NDT agencies shall be qualified and evaluated in accordance with Specification E543. The applicable edition of Specification E543 shall be specified in the contractual agreement.

6. Apparatus

6.1 *Electronic Apparatus*—The electronic apparatus shall be capable of energizing eddy current sensors with alternating currents of suitable frequencies and shall be capable of sensing the changes in the electromagnetic characteristics of the eddy current sensors. Equipment may include a detector, phase discriminator, filter circuits, gating circuits, and signaling devices as required for the particular application.

6.2 *Eddy Current Sensors*—Eddy current sensors shall be capable of inducing currents in the tube and sensing changes in the electrical characteristics of the tube. The eddy current sensors may be of the encircling coil (annular) type or surface probe type.

7. Standardization of Apparatus

7.1 The apparatus shall be adjusted with an appropriate reference standard to ensure that the equipment is operating at the proper level of sensitivity, with the following considerations:

7.1.1 Primary reference standards employed for this purpose shall be prepared in accordance with the methods described in X1.1.

7.1.1.1 Other primary standards including notches may be used if agreed upon by both purchaser and supplier. Documentations showing suitability of alternate standards should be available.

7.1.2 Equivalent secondary reference standards, prepared in accordance with methods described in X2.1, also may be employed for standardizing the apparatus.

7.1.2.1 Other secondary standards including notches may be used if agreed upon by both purchaser and supplier. Documentation showing suitability of alternate standards should be available.

7.1.3 Reference standards normally are of the same alloy, temper, and dimensions as the tube to be examined.

7.1.4 Examinations shall not be conducted unless the equipment can be set to the levels required by this standardization procedure.

7.1.5 For practical applications, reference standards also may be employed to establish quality control levels.

8. Procedure

8.1 Standardize the examination instrument using the appropriate reference standard prior to examination and check at least every 4 h during continuous operation, or whenever improper functioning of the examination apparatus is suspected. If improper functioning occurs, restandardize the apparatus in accordance with Section 7, and reexamine all tubes examined since the last successful standardization. Time between standardization can be increased based upon documented evidence of instrument stability but shall not exceed 12 h.

8.2 Tubes may be examined in the final drawn, annealed, or heat-treated temper, or in the drawn temper prior to the final anneal or heat treatment.

8.3 The length of tube over which end effect is significant may be determined by placing a series of holes or notches in special reference tubes and determining the distance from the tube end at which the signal amplitude from the discontinuities begins to decrease.

8.3.1 When standardizing and testing using secondary standard Method B (X2.5.2), if full length testing is required, the tube must be ordered to be electromagnetic tested in a rough cut length and have the untested 7 in. (175 mm) removed from each end.

NOTE 3—There is an area near each end which cannot be tested either