Designation: E 214 – 68 (Reapproved 1996)

An American National Standard

Standard Practice for Immersed Ultrasonic Examination by the Reflection Method Using Pulsed Longitudinal Waves[1]

This standard is issued under the fixed designation E 214; 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 Department of Defense.

1. Scope

1.1 This practice[2] describes in general terms an ultrasonic test procedure for detecting discontinuities in material using testing instruments which have been designed to transmit and receive pulsed longitudinal ultrasonic waves introduced into the material to be inspected through a liquid coupling agent.

NOTE 1—Practice E 1001 is a complementary document that extends Practice E 214 by describing more detailed procedures.

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:*

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks[3]

E 428 Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection[3]

E 1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves[3]

3. Application

3.1 This procedure applies to any material that can conduct sound waves of an appropriate frequency, and can be immersed in a liquid coupling agent for inspection, or can be subject to inspection by the use of a column or stream of the couplant through an appropriate container attached to the part or transducer.

4. Apparatus

4.1 *Electronic Apparatus*—The electronic apparatus shall be capable of producing, receiving, and displaying high-frequency electrical pulses at the required frequency and energy levels, and employ A-Scan; time base versus magnitude (Note 2). The instrument used should provide stable amplification of received pulses at the required test sensitivity levels. An appropriate line-voltage regulating transformer shall be used, if required, to ensure maximum stability.

NOTE 2—Other presentations, such as B-Scan and C-Scan, are available but are not covered in this practice.

4.2 *Immersion Search Units*—Immersible transducers for transforming electrical impulses into sound vibrations and vice versa, at the appropriate frequencies and energy levels shall be used. The transducers shall be capable of transmitting and receiving ultrasound to and from the immersed test specimen.

4.3 *Couplant*—The couplant, a liquid such as water, oil, glycerin, etc., capable of conducting ultrasonic vibrations from the transducer to the material being tested shall be used. Rust inhibitors, softeners, and wetting agents may be added to the couplant. The couplant liquid with all additives should not be detrimental to the surface condition of the test specimen or the container, and should wet the surface of the material to provide an intimate contact. Couplant may be heated to a comfortable working temperature and must be free of air bubbles.

4.4 *Manipulator*—The holder for the search tube and search unit that provides angular manipulation of the transducer for optimum response from the internal discontinuities. The maximum tolerance or play allowable in the manipulator and in the traversing unit should be adequate to permit ultrasonic testing at the sensitivity specified.

4.5 *Accessory Equipment*—Coaxial cables and search tubes used in conjunction with the electronic apparatus capable of conducting the electrical pulses while immersed in a liquid, and collimators for shaping the sound beam shall be used.

4.6 *Reference Blocks*—In order to correct for the many variables involved in ultrasonic testing, it is necessary to use references to establish instrument settings, assist reproducibility of techniques, and evaluate discontinuities. The fabrication of reference blocks should be governed by the requirements described in Practices E 127 or E 428.

5. Calibration of Apparatus

5.1 Prior to inspection, it is recommended that the ultrasonic system be standardized by means of ASTM reference blocks as

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[1] This practice is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Testing Procedures.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Practice SE-214 in the Code.

[3] *Annual Book of ASTM Standards*, Vol 03.03.

specified in the product specification. The equipment should be operated with the reference hole signal amplitude in the range between 25 % above the noise level and below the saturation level (usually between 25 and 75 % of full screen height). As an alternative, a system sensitivity may be established by adjusting the height of the first back reflection or number of multiple back reflections over an ultrasonically clean area as specified in the product specification.

5.2 If reference blocks are used, they should have ultrasonic characteristics, such as attenuation, noise level, and velocity similar to the metal being tested, or suitable correction should be made.

5.3 Ultrasonic characteristics should be evaluated by comparison of unsaturated first back-surface reflection or back-surface pattern from material tested with that of the reference standard with similar surface conditions, for example roughness and angularity. Any reduction of the back-reflection pattern is indicative of increased attenuation or loss of transmitted energy due to absorption or scatter within the material being tested, provided front- and back-surface roughness and parallelism of the test piece are approximately the same as that of the standard. In this case, correction for differences in acoustical properties should be made.

5.4 The distance between transducer and work should be adjusted to suit the particular size, type, and frequency of the transducer being used. However, in no case should the couplant distance allow an entry surface signal or first interface signal to interfere with the first order metal-travel distance in the A-scan presentation. The transducer-work couplant distance should be held equal, within ±¼ in. (6.4 mm), to that established with the related reference standard.

5.5 Reference standards should be spot-checked at least hourly to ensure that the ultrasonic system calibration is not drifting.

6. Procedure

6.1 *Testing Surface*—Surfaces shall be uniform and free of loose scale machining or grinding particles, discontinuities such as pits or gouges, or foreign matter. In the case of steel, scale reasonably smooth and securely bonded to the metal need not be removed for testing. The surface must be adequate to permit ultrasonic inspection at the sensitivity specified.

6.2 *Test Frequency*—Select a suitable test frequency after due consideration of the material thickness and the minimum discontinuity that is to be detected, plus the attenuation factor of the material to be tested. Theoretically, the higher the frequency, the smaller the detectable discontinuity. However, increasing attenuation, noise level, and surface conditions may be a limiting factor at higher frequencies.

6.3 *Scanning*—The transducer may be hand-held, in which case use some guide such as a plastic tube in order to hold the transducer-part distance and geometrical relationship constant. For mechanical scanning, the transducer may be mounted in a search tube that is held in a manipulator or fixture and moved over the surface of the part being tested by some mechanical means. When appropriate, the part may be moved past a fixed transducer. The scanning may be continuous or intermittent over designated areas as outlined by the requirements of design and specification of the part. For continuous scanning, the transducer indexing must be adequate to provide 100 % coverage at the test sensitivity and test distance. Select a scanning speed such as to permit detection of the smallest discontinuities referenced in the specification and slow enough to allow any recording or signalling device to function.

6.4 Make evaluation of ultrasonic indications after reflections are maximized by angular manipulation of the transducer over the indication. In the case of scanning by hand or using some device other than a rigidly mounted manipulator, the transducer-work couplant distance should be carefully maintained as referenced under Section 5.

6.5 Establish the scanning of the material being inspected so that volumes to be tested are adequately penetrated by the sonic beam. Determine the suitability of reference test blocks for evaluating the ultrasonic indications by the similarity in attenuation and velocity between reference standards and the material being tested. In general, reference standards from one wrought aluminum alloy are representative of most wrought aluminum alloys, and 4130 or 4340 steel alloy standards are representative of most low-alloy carbon steels. Consider any significant difference in attenuation between reference standards and the part or material being tested during the scanning procedure, and make corrections in interpretations of the reflection amplitudes for differences in attenuation.

7. Test Data Record

7.1 The following data should be recorded at the time of each test for future reference:

7.1.1 Date and part number for identification,

7.1.2 Inspector,

7.1.3 Type of instrument, make, model, and serial number,

7.1.4 Test frequency,

7.1.5 Transducer type and effective beam size, collimator, cable length, tuning network, and water travel,

7.1.6 References,

7.1.7 Amplitude or response from the discontinuities of a known size in the reference blocks used and back-reflection information (attenuation) from same. If other references are used, a statement of procedure should be included.

7.1.8 Results of test (number, classification, and location of discontinuities).

8. Interpretation of Results

8.1 Internal discontinuities may be located and their estimated magnitude established by the foregoing procedure. The results and subsequent action shall be agreed upon by the purchaser and material supplier as part of the job requirements.

9. Report

9.1 The report should reference this practice and applicable test parameters agreed upon with the material supplier in order that the result of different testing groups can be correlated.

9.2 Parts meeting the quality requirements agreed upon between the purchaser and the manufacturer should be identified and listed as required, and certified as to meeting the applicable specification requirements.

9.3 Parts that will have to be handled through action by an agency such as the aircraft industries Material Review Board or other discrepant procedure shall be completely recorded with

ultrasonic information showing size and location of discontinuities, accompanied by a sketch showing the size and location of the indications.

10. Keywords

10.1 immersed; Immersed Ultrasonic NDT; nondestructive testing; pulse-reflection method; pulsed longitudinal waves; ultrasonic nondestructive examination