Designation: E 214 – 01

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 an ultrasonic examination procedure for detecting discontinuities in material using instruments that transmit and receive pulsed longitudinal ultrasonic waves introduced into the material to be examined while immersed in or impinged upon by a liquid coupling agent. This practice 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 between the search unit and the material being examined.

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]

E 1316 [3]

2.2 *ASNT Documents*

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

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

2.3 *Aerospace Industries Association Document*

National Aerospace Standard NAS 410, NAS Certification and Qualification of Nondestructive Test Personnel[5]

2.4 *Military Specifications*

MIL-STD-410, Nondestructive Testing Personnel Certification and Qualification[6]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E 1316.

4. Basis of Application

4.1 Personnel Qualification. If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, MIL-STD-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.

4.2 Written Procedure. A detailed written procedure shall be used for the performance of ultrasonic examinations in accordance with this practice. The written procedure should address all applicable portions of this practice, for the purposes of consistency in application and the repeatability of the examination results. Specific requirements regarding the preparation and approval of the written procedure should be determined by the purchaser and supplier agreement.

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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 E07.06 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.

[4] Available from the American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, columbus, OH 43228-0518.

[5] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY, 10036

[6] Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA, 19111-1054, Attn: NPODS.

5. Apparatus

5.1 *Electronic Apparatus*—The electronic apparatus shall be capable of producing, receiving, and displaying electrical pulses at the required frequency and energy levels, and employ A-Scan; time base versus magnitude (Note 2). Appropriate means shall be employed to ensure electronic instrument stability in the presence of typical line-voltage fluctuations and temperature and humidity extremes at the examination site.

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

5.2 *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.

5.3 *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.

5.4 *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.

5.5 *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.

5.6 *Reference Blocks*—To correct for the many variables involved in ultrasonic examination, it is necessary to use references to establish instrument settings, assist reproducibility of techniques, and evaluate discontinuities. Such reference blocks, often called test blocks or reference standards, are used to standardize the equipment and evaluate the indications received from reflectors or discontinuities within the material being examined. The ultrasonic characteristics of the reference standards such as attenuation, noise level, surface condition, and velocity should be similar to the material being examined. The material characteristics and the size and type of reference reflectors used in the reference blocks should be established in the contractual documents. Practices E 127 and E 428 address the fabrication and control of aluminum and steel reference blocks, respectively.

NOTE 3—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-carbon alloy steels.

6. Standardization of Apparatus

6.1 The ultrasonic system should be standardized by means of reference blocks as specified in the product specification. Other alternative setups may be employed depending upon the type of reference reflector specified and as given in the detailed procedure.

6.2 If reference blocks are used, they should have ultrasonic characteristics, such as attenuation, noise level, and velocity similar to the material being examined, or suitable correction should be made. Ideally, the reference block should have the same geometric as well as ultrasonic characteristics as the material to be examined. These include section thickness as well as surface curvature and roughness.

6.3 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.

6.4 The distance between search unit and work should be adjusted to suit the particular size, type, and frequency of the search unit being used. The search unit-to-part spacing should be such that the multiple-entry- or back-surface reflections do not fall within the area of interest. The search unit-to-part couplant distance shall be maintained to a sufficient accuracy to prevent a change in sensitivity during scanning.

6.5 Periodic verification of standardization shall be performed at full scanning speed and increment. Any indication of a decrease in sensitivity that could have resulted in a missed defect shall require reexamination of all pieces tested since the last successful standardization.

7. Procedure

7.1 *Examination 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.

7.2 *Examination 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.

7.3 *Scanning*—The search unit may be hand-held, in which case use a guide to hold the search unit-part distance and geometrical relationship constant. For mechanical scanning, the search unit may be mounted in a search tube that is held in a manipulator or fixture and moved over the surface of the part being examined by some mechanical means. When appropriate, the part may be moved past a fixed search unit. 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 search unit

indexing must be adequate to provide 100 % coverage at the examination sensitivity and examination distance. Typical ways to ensure adequate coverage include requiring a 10 % scan overlap based upon the measured effective beam width, or requiring that the reference reflector be detected at rejectable amplitude on a minimum of two consecutive scan passes. 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.

7.4 Evaluate ultrasonic indications after the indications are maximized by angular manipulation and/or positional translation of the search unit over the reflector. In the case of scanning by hand or using some device other than a rigidly mounted manipulator, the search unit-work couplant distance should be carefully maintained as referenced under Section 5.

7.5 Establish the scanning of the material so that volumes to be examined are adequately penetrated by the ultrasonic beam. Determine the suitability of reference blocks for evaluating the ultrasonic indications by the similarity in attenuation, velocity, and geometry between the reference blocks and the material being examined. Consider any significant difference in attenuation between the reference blocks and the part or material being examined during the scanning procedure, and make corrections in interpretations of the reflection amplitudes for differences in these properties.

8. Test Data Record

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

8.1.1 Date and part number for identification,

8.1.2 Specific examination procedure used,

8.1.3 Examiner,

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

8.1.5 Examination frequency, instrument settings,

8.1.6 Search unit type and effective beam size, collimator, cable length, tuning network, water travel, examination step size, and search unit travel speed,

8.1.7 Reference block identification,

8.1.8 Amplitude of response from the artificial targets of known size in the reference blocks, or other reference blocks, and back-reflection comparisons of blocks to material.

8.1.9 Results of examination (number, classification, and location of discontinuities).

9. Interpretation of Results

9.1 Internal and surface-breaking discontinuities may be detected using the procedure given. The indication amplitude, length, depth, location, or type are all characteristics from which the accept or reject decision might be made. Any detected indications should be determined as nonrelevant or relevant, and then acceptable or not based upon the acceptance criteria supplied by the Customer.

10. Report

10.1 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.

10.2 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.

10.3 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.

11. Keywords

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