Designation: E114 – 95 (Reapproved 2005)

Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method[1]

This standard is issued under the fixed designation E114; 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] covers ultrasonic examination of materials by the pulse-echo method using straight-beam longitudinal waves introduced by direct contact of the search unit with the material being examined.

1.2 This practice shall be applicable to development of an examination procedure agreed upon by the users of the document.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *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]

E317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ASNT Standards:*[4]

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

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

2.3 *Other Documents:*

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

3. Terminology

3.1 Refer to Terminology E1316 for definitions of terms used in this practice.

4. Basis of Application

4.1 *Purchaser-Supplier Agreements*:

The following items require agreement between the using parties for this practice to be used effectively:

4.1.1 *Qualification of Nondestructive Testing Agencies*—Agreement is required as to whether the nondestructive testing agency, as defined in Practice E543 must be formally evaluated and qualified to perform the examination. If such evaluation and qualification is specified, a documented procedure such as Practice E543 shall be used as the basis for evaluation.

4.1.2 *Personnel Qualification*—Nondestructive testing (NDT) personnel shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, NAS-410, or a similar document. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

4.1.3 *Extent of Examination*—The extent of the examination shall be determined by agreement of the using parties.

4.1.4 *Time of Examination*—The time of examination shall be determined by agreement of the using parties.

4.1.5 *Interpretation Criteria*—The criteria by which the ultrasonic signals and part acceptability will be evaluated and shall be determined by agreement of the using parties.

5. Significance and Use

5.1 A series of electrical pulses is applied to a piezoelectric element (transducer) which converts these pulses to mechanical energy in the form of pulsed waves at a nominal frequency. This transducer is mounted in a holder so it can transmit the waves into the material through a suitable wear surface and

[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 Method.

Current edition approved Dec. 1, 2005. Published February 2006. Originally approved in 1955. Last previous edition approved in 2001 as E114 - 95 (2001). DOI: 10.1520/E0114-95R05.

[2] For ASME Boiler and Pressure Vessel Code applications see related Practice SE-114 in Section II of that 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 American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

[5] Available from Aerospace Industries Association of America, Inc. (AIA), 1250 Eye St., NW, Washington, DC 20005.

couplant. The assembly of transducer, holder, wearface, and electrical connnector comprise the search unit.

5.2 Pulsed energy is transmitted into materials, travels in a direction normal to the contacted surface, and is reflected back to the search unit by discontinuity or boundary interfaces which are parallel or near parallel to the contacted surface. These echoes return to the search unit, where they are converted from mechanical to electrical energy and are amplified by a receiver. The amplified echoes (signals) are usually presented in an A-scan display, such that the entire round trip of pulsed energy within the resolution of the system may be indicated along the horizontal base line of the display by vertical deflections corresponding to echo amplitudes from each interface, including those from intervening discontinuities. By adjustment of the sweep (range) controls, this display can be expanded or contracted to obtain a designated relation between the displayed signals and the material reflectors from which the signal originates. Thus a scaled distance to a discontinuity and its displayed signal becomes a true relationship. By comparison of the displayed discontinuity signal amplitudes to those from a reference standard, both location and estimated discontinuity size may be determined. Discontinuities having dimensions exceeding the size of the sound beam can also be estimated by determining the amount of movement of a search unit over the examination surface where a discontinuity signal is maintained.

NOTE 1—When determining the sizes of discontinuities by either of these two practices, only the area of the discontinuity which reflects energy to the search unit is determined.

5.3 Types of information that may be obtained from the pulsed-echo straight-beam practice are as follows:

5.3.1 Apparent discontinuity size (Note 2) by comparison of the signal amplitudes from the test piece to the amplitudes obtained from a reference standard.

5.3.2 Depth location of discontinuities by calibrating the horizontal scale of the A-scan display.

5.3.3 Material properties as indicated by the relative sound attenuation or velocity changes of compared items.

5.3.4 The extent of bond and unbond (or fusion and lack of fusion) between two ultrasonic conducting materials if geometry and materials permit.

NOTE 2—The term “apparent” is emphasized since true size depends on orientation, composition, and geometry of the discontinuity and equipment limitations.

6. Apparatus

6.1 Complete ultrasonic apparatus shall include the following:

6.1.1 *Instrumentation*—The ultrasonic instrument shall be capable of generating, receiving, and amplifying high-frequency electrical pulses at such frequencies and energy levels required to perform a meaningful examination and to provide a suitable readout.

6.1.2 *Search Units*—The ultrasonic search units shall be capable of transmitting and receiving ultrasound in the material at the required frequencies and energy levels necessary for discontinuity detection. Typical search unit sizes usually range from ⅛ in. [3.2 mm] in diameter to 1⅛ in. [28.6 mm] in diameter with both smaller and larger sizes available for specific applications. Search units may be fitted with special shoes for appropriate applications. Special search units encompassing both a transmitter and a receiver as separate piezoelectric elements can be utilized to provide some degree of improved resolution near the examination surface.

6.1.3 *Couplant*—A couplant, usually a liquid or semi-liquid, is required between the face of the search unit and the examination surface to permit or improve the transmittance of ultrasound from the search unit into the material under test. Typical couplants include water, cellulose gel, oil, and grease. Corrosion inhibitors or wetting agents or both may be used. Couplants must be selected that are not detrimental to the product or the process. The couplant used in standardization should be used for the examination. During the performance of a contact ultrasonic examination, the couplant layer between search unit and examination material must be maintained such that the contact area is held constant while maintaining adequate couplant thickness. Lack of couplant reducing the effective contact area or excess couplant thickness will reduce the amount of energy transferred between the search unit and the examination piece. These couplant variations in turn result in examination sensitivity variations.

6.1.3.1 The couplant should be selected so that its viscosity is appropriate for the surface finish of the material to be examined. The examination of rough surfaces generally requires a high-viscosity couplant. The temperature of the material’s surface can change the couplant’s viscosity. As an example, in the case of oil and greases, see Table 1.

6.1.3.2 At elevated temperatures as conditions warrant, heat-resistant coupling materials such as silicone oils, gels, or greases should be used. Further, intermittent contact of the search unit with the surface or auxiliary cooling of the search unit may be necessary to avoid temperature changes that affect the ultrasonic wave characteristics of the search unit. At higher temperatures, certain couplants based on inorganic salts or thermoplastic organic materials, high-temperature delay materials, and search units that are not damaged by high temperatures may be required.

6.1.3.3 Where constant coupling over large areas is needed, as in automated examination, or where severe changes in surface roughness are found, other couplants such as liquid gap coupling will usually provide a better examination. In this case, the search unit does not contact the examination surface but is separated by a distance of about 0.2 in. [0.5 mm] filled with couplant. Liquid flowing through the search unit fills the gap.

TABLE 1 Suggested Viscosities—Oil Couplants

NOTE 1—The table is a guide only and is not meant to exclude the use of a particular couplant that is found to work satisfactorily on a particular surface.

Approximate Surface Roughness Average (Ra), µin. [µm]	Equivalent Couplant Viscosity, Weight Motor Oil
5–100 [0.1–2.5]	SAE 10
50–200 [1.3–5.1]	SAE 20
100–400 [2.5–10.2]	SAE 30
250–700 [6.4–17.8]	SAE 40
Over 700 [18–]	cup grease