Designation: E2700 – 14

Standard Practice for Contact Ultrasonic Testing of Welds Using Phased Arrays[1]

This standard is issued under the fixed designation E2700; 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 describes ultrasonic techniques for inspecting welds using phased array ultrasonic methods (see Note 1).

1.2 This practice uses angle beams, either in S-scan or E-scan modes, primarily for butt welds and Tee welds. Alternative welding techniques, such as solid state bonding (for example, friction stir welding) and fusion welding (for example, electron beam welding) can be inspected using this practice provided adequate coverage and techniques are documented and approved. Practices for specific geometries such as spot welds are not included. The practice is intended to be used on thicknesses of 9 to 200 mm (0.375 to 8 in.). Greater and lesser thicknesses may be tested using this standard practice if the technique can be demonstrated to provide adequate detection on mockups of the same wall thickness and geometry.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.*

NOTE 1—This practice is based on experience with ferrous and aluminum alloys. Other metallic materials can be examined using this practice provided reference standards can be developed that demonstrate that the particular material and weld can be successfully penetrated by an ultrasonic beam.

NOTE 2—For additional pertinent information, see Practices E2491, E317, and E587.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E164 Practice for Contact Ultrasonic Testing of Weldments

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

E587 Practice for Ultrasonic Angle-Beam Contact Testing

E1316 Terminology for Nondestructive Examinations

E2192 Guide for Planar Flaw Height Sizing by Ultrasonics

E2491 Guide for Evaluating Performance Characteristics of Phased-Array Ultrasonic Testing Instruments and Systems

2.2 *ASME Standard:*[3]

ASME B and PV Code Section V, Article 4

2.3 *ISO Standards:*[4]

ISO 2400 Reference Block for the Calibration of Equipment for Ultrasonic Examination

ISO 9712 Nondestructive Testing—Qualification and Certification of NDT Personnel

2.4 *ASNT Documents:*[5]

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

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

2.5 *AIA Standard:*[6]

NAS-410 Certification and Qualification of Nondestructive Testing Personnel

3. Terminology

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

4. Summary of Practice

4.1 Phased arrays are used for weld inspections for numerous applications. Industry specific requirements have been developed to control the use of this technology for those applications. A general standard practice document is required

[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.

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[2] 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.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

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

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

to define the requirements for wider use of the technology. Several manufacturers have developed portable, user-friendly instruments. Codes and code cases have been developed, or are being developed, to cover phased array weld inspection requirements by organizations such as ASME. Practice E2491 covers setting up of phased arrays for weld inspections. Training programs for phased arrays have been set up worldwide. This practice provides procedural guidance for both manual and mechanized scanning of welds using phased array systems.

5. Significance and Use

5.1 Industrial phased arrays differ from conventional monocrystal ultrasonic transducers since they permit the electronic control of ultrasound beams. The arrays consist of a series of individual transducer elements, each separately wired, time-delayed and electrically isolated; the arrays are typically pulsed in groups to permit "phasing," or constructive-destructive interference.

5.2 Though primarily a method of generating and receiving ultrasound, phased arrays are also a method of scanning and imaging. While some scan patterns emulate manual technology, other scans (for example, S-scans) are unique to phased arrays. With their distinct features and capabilities, phased arrays require special set-ups and standardization, as addressed by this practice. Commercial software permits the operator to easily make set ups without detailed knowledge of the phasing requirements.

5.3 Phased arrays can be used in different ways: manual or encoded linear scanning; and different displays or combinations of displays. In manual scanning, the dominant display will be an S-scan with associated A-scans. S-scans have the advantage over E-scans that all the specified inspection angles can be covered at the same time.

5.4 The main advantages of using phased arrays for ultrasonic weld examinations are:

5.4.1 Faster scanning due to multiple angles on display at the same time,

5.4.2 Better imaging from the true depth S-scan,

5.4.3 Data storage, for example, selected reflectors, for auditing, and archiving.

5.4.4 Rapid and reproducible set-ups with electronic instruments.

6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this standard.

6.2 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, ISO 9712, NAS-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.

6.2.1 In addition, there should also be training or knowledge and experience related to phased array equipment and techniques. Personnel performing examinations to this standard should list the qualifying credentials in the examination report.

6.3 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

6.4 *Procedures and Techniques*—The procedures and techniques to be used shall be as specified in the contractual agreement. Practice E2491 recommends methods of assessing performance characteristics of phased array probes and systems.

6.5 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with 9.1 unless otherwise specified.

6.6 *Timing of Examination*—The timing of examination shall be determined by the contracting parties and in accordance with the stage of manufacture or in-service conditions.

6.7 *Extent of Examination*—The extent of examination shall be suitable to examine the volume of the weld plus the heat affected zone unless otherwise specified.

6.8 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with 13.1, unless otherwise specified. Since acceptance criteria are not specified in this standard, they shall be specified in the contractual agreement.

6.9 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this standard and if required shall be specified in the contractual agreement.

7. Equipment

7.1 *Phased Array Instruments:*

7.1.1 The ultrasonic phased array instrument shall be a pulse echo type and shall be equipped with a standardized dB gain or attenuation control stepped in increments of 1 dB minimum, containing multiple independent pulser/receiver channels. The system shall be capable of generating and displaying both B-scan and S-scan images, which can be stored and recalled for subsequent review.

7.1.2 The phased array system shall have on-board focal law generation software that permits direct modification to ultrasonic beam characteristics. Specific delay calculations may be performed by the system itself or imported from external calculations.

7.1.3 The phased array system shall have a means of data storage for archiving scan data. An external storage device, flash card or USB memory stick can be used for data storage. A remote portable PC connected to the instrument may also be used for this purpose. If instruments do not inherently store A-scan data, such as some manual instruments, the final image only may be recorded.

7.1.4 The phased array system shall be standardized for amplitude and height linearity in accordance with Practice E2491 annually, as a minimum.