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Standard Practice for Use of the Ultrasonic Time of Flight Diffraction (TOFD) Technique[1]

This standard is issued under the fixed designation E 2373; 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 establishes the requirements for developing ultrasonic examination procedures using the ultrasonic technique known as Time-of-Flight Diffraction (TOFD).

~~1.2The values stated in SI units are to be regarded as standard. Inch-pound units are provided for information.~~

~~1.3Consistent~~ 1.2 Consistent with ASTM Policy, TOFD may be regarded as an ultrasonic test method whereby the qualities and characteristics of the item tested are evaluated, measured and in some cases identified. Measurements may be subject to precision and bias that may be determined statistically or as a function of some parameter(s) such as wavelength. This practice may be used for applications that would be qualitative and properly addressed as examinations as well as quantitative and more properly addressed as tests.

1.3 The values stated in SI units are to be regarded as standard. Inch-pound units are provided for information.

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:*[2]

E 164 ~~Practice for Ultrasonic Contact Examination of Weldments~~ Practice for Contact Ultrasonic Testing of Weldments

E 543 Specification for Agencies Performing Nondestructive Testing

E 1065 Guide for Evaluating Characteristics of Ultrasonic Search Units

E 1316 Terminology for Nondestructive Examinations

E 1324 Guide for Measuring Some Electronic Characteristics of Ultrasonic Examination Instruments

[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.

2.2 *ASNT Documents:*[3]
SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification
ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
2.3 *Aerospace Industries Association Document:*[4]
NAS-410 Certification and Qualification of Nondestructive Testing Personnel
2.4 *Other Documents:*
BS 7706 (1993) Guide to Calibration and Setting-up of the Ultrasonic Time-of-Flight Diffraction (TOFD) Technique for Detection, Location and Sizing of Flaws, British Standards Institute, 1993[5]
Code Case 2235 ASME Boiler and Pressure Vessel Code[6]

3. Terminology

3.1 *Definitions*—Related terminology is defined in Terminology E 1316.
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *B-scan display*—a sectional view of the plotted inspection data formed by the stacking of A-scans. (Some users refer to stacked A-scans from non-parallel scans as D-scans and reserve those used with parallel scans as B-scans.)
3.2.2 *back-wall echo*—a specular reflection from the back-wall of the component being examined (usually assumed to be a plate).
3.2.3 *lateral wave*—a compression wave that travels by the most direct route from the transmitting probe to the receiving probe in a TOFD configuration.
3.2.4 *parallel scan*—a scan whereby the probe pair motion is parallel to the ultrasonic beam axis. Also called a B-scan by some users.
3.2.5 *PCS*—abbreviation for probe center spacing. Refers to the distance between the marked exit points of a pair of TOFD probes for a specific application.
3.2.6 *non-parallel or longitudinal scan*—a scan whereby the probe pair motion is perpendicular to the ultrasonic beam axis.
3.2.7 *RF waveforms*—the non-rectified A-scan.

4. Significance and Use

4.1 This practice provides general principles for the application of the Time-of-Flight Diffraction Technique as a tool for detection and sizing of discontinuities.
4.2 TOFD is a nondestructive ultrasonic examination technique that is not based on amplitude response. However, sufficient sensitivity is required to identify indications for evaluation.
4.3 Techniques used are typically applied to welded joints in carbon steel but the principles may be applicable to other applications including other materials with suitable validation procedures agreeable to the contracting parties.
4.4 In addition to a stand-alone ultrasonic detection technique TOFD may be used in conjunction with weld examinations such as those described in Practices E 164 and E 1961 where it may be used to improve sizing estimates of flaws detected by the manual or mechanized pulse-echo techniques and help discriminate between flaws and geometric reflectors.
4.5 The technique has proven effective on thicknesses from 9 to 300 mm ~~[0.375~~(0.375 to 12 ~~in.]~~.in.). TOFD has been used on thicknesses outside of this range but special considerations are necessary. Techniques developed outside of this range of thickness shall be demonstrated as capable of meeting the required detection and sizing requirements of the specification used.

5. Basis of Application

5.1 The following items are subject to contractual agreement between the parties using or referencing this standard.
5.2 *Personnel Qualification*
5.2.1 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, 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.
5.3 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in E 543. The applicable edition of E 543 shall be specified in the contractual agreement.

~~[3] Available from BSI Management Systems, 12110 Sunset Hills Road, Suite 140, Reston VA 20190.~~
[3] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.
~~[4] Available from the American Society of Mechanical Engineers, ASME International, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900.~~
[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.
~~[5] Reference to ASME CC2235 is made only as an example of an existing code where the mutually agreed upon acceptance criteria allows TOFD to be applied. This does not suggest that application of ASME CC2235 would be appropriate in all cases. It should be recognized that the high sensitivity of the TOFD technique could result in indications from reflectors in plate materials that meet all plate ultrasonic specification requirements. Such indications should not be considered unacceptable unless they fail to meet the acceptance criteria agreed upon in 7.1.~~
[5] Available from BSI Management Systems, 12110 Sunset Hills Road, Suite 140, Reston VA 20190.
[6] Available from the American Society of Mechanical Engineers, ASME International, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900.