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Standard Practice for Examination of Seamless, Gas-Filled, Steel Pressure Vessels Using Angle Beam Ultrasonics[1]

This standard is issued under the fixed designation E 2223; 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 a contact angle-beam shear wave ultrasonic technique to detect and locate the circumferential position of longitudinally oriented discontinuities and to compare the amplitude of the indication from such discontinuities to that of a specified reference notch. This practice does not address examination of the vessel ends. The basic principles of contact angle-beam examination can be found in Practice E 587. Application to pipe and tubing, including the use of notches for standardization, is described in Practice E 213.

1.2 This practice is appropriate for the ultrasonic examination of cylindrical sections of gas-filled, seamless, steel pressure vessels such as those used for the storage and transportation of pressurized gasses. It is applicable to both isolated vessels and those in assemblies.

1.3 The practice is intended to be used following an Acoustic Emission (AE) examination of stacked seamless gaseous pressure vessels (with limited surface scanning area) described in Test Method E 1419.

1.4 This practice does not establish acceptance criteria. These are determined by the reference notch dimensions, which must be specified by the using parties.

NOTE 1—Background information relating to the technical requirements of this practice can be found in the references sited in Test Method E 1419, Appendix X1.

1.5 Dimensional values stated in in-pound units are regarded as standard; SI equivalents, in parentheses may be approximate.

1.6 *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 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 543~~Practice~~ Specification for Agencies Performing Nondestructive Testing

E 587 Practice for Ultrasonic Angle-Beam Examination by the Contact Method

E 1316 Terminology for Nondestructive Examinations

E 1419~~Test Method for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission[2]~~ Test Method for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission

E 2192 Guide for Planar Flaw Height Sizing by Ultrasonics

2.2 *ASNT Documents:*[3]

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

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

2.3 *AIA Document:*

NAS-410 Nondestructive Testing Personnel Qualification and Certification[4]

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[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and are 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* ~~, Vol 03.03.~~volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from the American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, OH 43228-0518.

[4] Available from Aerospace Industries Association of America, Inc., 1250 Eye St., NW, Washington, DC ~~20005.~~20005.

3. Terminology

3.1 Terminology relating to this practice for angle-beam shear wave ultrasonic examination is defined in Terminology E 1316.

4. Summary of Methodology

4.1 An ultrasonic pulse-echo contact angle-beam, shear wave technique with the beam directed circumferentially is used to locate surface breaking discontinuities in the cylindrical wall of a pressure vessel. The amplitude of the reflected signal from the discontinuity is compared to that of a known reference notch. Scanning is performed in both clockwise and counter clockwise directions to detect and confirm the position of the discontinuity identified in the AE examination report.

5. Significance and Use

5.1 The purpose of this practice is to provide a procedure for locating, detecting and estimating the relevance of longitudinally oriented crack-like discontinuities which have been previously indicated by AE examination.

5.2 This practice may be used for a pressure vessel that is situated in such a way as to limit access to the vessel's wall. Typical examples include tube trailers and gas tube railroad cars. Since the pressure vessels are stacked horizontally in a frame, with limited space between them, the circumferential location of a discontinuity may be a distance away from the search unit (several skip distances).

5.3 This practice has been shown to be effective for cylinders between 9 in. (229 mm) and 24 in. (610 mm) in diameter and wall thicknesses between ¼ in. (6.4 mm) to 1 in. (26 mm) with discontinuities that are oriented longitudinally in pressure vessel sidewall.

5.4 To ~~be~~ reliably ~~detected~~detect discontinuities by the procedure in this practice, a significant part of the reflecting surface must be transverse to the beam direction.

5.5 Evaluation of possible discontinuity in the end faces indicated by AE is not covered by this practice.

6. Basis of Application

6.1 *Personnel Qualification*

6.1.1 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, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The standard used and its applicable revision shall be specified by the regulatory authority, or stated in the contractual agreement, or both.

6.1.2 *Additional Personnel Training*

6.1.2.1 Personnel performing this type of examination shall have additional training in the following topics.

6.1.3 Construction and manufacturing techniques for seamless steel pressure vessels.

6.1.4 Familiarity with the types of discontinuities that may occur in this type of pressure vessels.

6.2 *Qualification of Nondestructive Agencies*

6.2.1 If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in the applicable Sections 5 through 9 of Practice E 543. The applicable edition shall be specified by the regulatory authority, or stated in the contractual agreement, or both.

6.3 *Extent of Examination*

6.3.1 The extent of the examination shall be in accordance with the procedures in Sections 9 and 10 unless otherwise specified.

6.3.2 The reference notch dimensions shall be specified by the regulatory authority, or stated in the contractual agreement, or both.

6.4 *Reporting Criteria*

6.4.1 Reporting criteria for the examination results shall be in accordance with Section 11 unless otherwise specified. Since acceptance criteria are not specified in this standard, they shall be defined in accordance with Section 8 and by the regulatory authority or stated in the contractual agreement.

6.5 *Reexamination of Repaired/Reworked Items*

6.5.1 Reexamination of repaired/reworked items is not addressed in this standard and if required shall be specified by the regulatory authority, or stated in the contractual agreement, or both.

7. Apparatus

7.1 Ultrasonic pulse-echo instrumentation shall have a minimum capacity of examining at center frequencies from 2¼ to 5 MHz. The instrument, search units and related equipment shall be cable of displaying the peak amplitude of the indication from the reference notch in the standardization ring, as described in Section 8, and locating its circumferential position over the full sweep range required for coverage of the vessel to be examined.

7.1.1 Each search unit used for this technique shall have the appropriate frequency and refracted angle for the material and geometry of the pressure vessel that is being examined. The frequency and angle of the search unit is selected during standardization and is related to diameter, wall thickness and the type of steel used for the vessel and corresponding standardization rings.

7.1.1.1 The angle and frequency of the search unit to be used shall be determined by using different search units on a

~~reference~~standardization ring that represents the examination piece. A search unit which can satisfactorily detect and display the indication from the notch in the ~~reference~~standardization ring at the maximum distance to be used during the examination shall be selected for setting up the Distance Amplitude Correction (DAC) curve for examination in accordance with 9.3.

7.1.1.2 Select search units for evaluation from those having frequencies 2 ¼ and 5 MHz with refracted angles of 45° to 75° in steel, and in available commercial sizes. Those producing the required sensitivity and DAC response on the appropriate ~~reference~~standardization ring are acceptable. These search units have generally been found satisfactory for the examination of the type of vessels specified in 5.3.

7.1.1.3 The search unit shall be comprised of a transducer mounted on a plastic wedge that is designed to have continuous acoustic coupling between search unit and the pressure vessel wall.

NOTE 2—This is usually accomplished with a wedge that is radiused to match the cylinder diameter.

7.2 Couplant for this practice shall be a liquid that is used between the ultrasonic search unit and examination piece to remove the air and transmit ultrasonic waves. Water is a preferred couplant. Other couplant such as oil or glycerin may be used. Couplant shall be the same for both standardization and actual examination. Care shall be taken to ensure that the couplant does not freeze when the examination is conducted at low temperatures.

8. Standardizing Ring with Reference Notches

~~8.1The reference ring shall be fabricated from the same type of pressure vessel that is being examined. That is, reference ring must have the same diameter, wall thickness, material, heat treatment, and surface condition as the vessel to be examined.~~

~~8.1.1Reference notches will be placed into both internal and external surfaces of the reference ring, see~~

8.1 The standardization ring shall be fabricated from the same type of pressure vessel that is being examined. That is, standardization ring must have the same diameter, similar wall thickness, material, heat treatment, and surface condition as the vessel to be examined.

NOTE 3—Since seamless pressure vessels tend to have a variation in wall thickness within a given cross section at any axial length of the cylinder and along the length of a given cylinder, due consideration must be given when selecting the standardization ring.

8.1.1 Reference notches will be placed into both internal and external surfaces of the standardization ring, see Fig. 1. The preferred notch fabrication method is by the EDM process.

8.1.2 The inner surface and outer surface notches may be placed into a single ~~reference~~standardization ring. However, where practical, separate rings may be used, see Fig. 1.

8.1.3 Notch dimensions must be specified by the using parties for each type and size of vessel.

9. Standardization Procedure

9.1 The instrument sweep shall be adjusted to encompass the sound path to be used during the examination.

9.2 Place couplant and search unit on the outside surface of the standardization ring and adjust the gain (sensitivity) and location of the search unit until the indication from the internal notch is identified. Temperature of the ~~reference~~standardization ring during standardization should be the same as the temperature of the pressure vessel that is being examined.

9.3 The search unit is located at a close distance (half-skip distance) from the designated internal notch on the surface of the ~~reference~~standardization ring. Increase the gain until the signal is maximized at 80% of the full screen height as shown in Fig. 2.

~~9.3.1Without adjusting the gain, obtain three additional indications from the notch with the search unit located at 90-, 120- and 180-degree positions around the ring's circumference by moving the search unit on the ring, away from each notch. It may be necessary to increase the horizontal display range control on the instrument. The minimum signal height should not be below 10% full screen height.~~

~~9.3.2The position and maximum peak of each indication at 90-, 120- and 180-degree positions is marked on the display screen. A DAC curve is constructed by connecting the signal peaks.~~

9.3.1 Without adjusting the gain, obtain additional indications (3 or more) from the notch with the search unit increasing beam path distances by moving the search unit on the ring, away from each notch.

9.3.2 The position and maximum peak of each indication determined from 9.3.1 is marked on the display screen. A DAC curve is constructed by connecting the signal peaks. Fig. 2 illustrates a typical DAC curve display for two internal notches with different depths.

~~9.3.3Since the skip distances vary with vessel geometry, a separate DAC shall be produced for each type of pressure vessel. The last point of the DAC curve shall be at a known distance on the reference ring (not be less than ½ the circumference of the ring).~~

9.3.3 Since the skip distances vary with vessel geometry, a separate DAC curve shall be produced for each type of pressure vessel. The last point of the DAC curve shall be at a known distance on the standardization ring. The maximum scanning distance shall not exceed the distance corresponding to the last point on DAC curve.

9.3.4 The same procedure shall be used to generate DAC curves for internal and external notches.

9.3.5 Some ultrasonic instrumentation may have the capability to provide electronic compensation such as time-varied gain (TVG/STC), digitized storage and display of Distance Amplitude (D-A) response curve or Distance Amplitude Gate functions (DAG). Application of these functions may require modification of the prescribed procedures. Refer to the Manufacturers operational instructions.