Designation: E273 – 20

Standard Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing[1]

This standard is issued under the fixed designation E273; 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 U.S. Department of Defense.

1. Scope*

1.1 This practice[2] describes general ultrasonic testing procedures for the detection of discontinuities in the weld and adjacent heat affected zones of welded pipe and tubing by scanning with relative motion between the search unit and pipe or tube. When contact or unfocused immersion search units are employed, this practice is intended for tubular products having specified outside diameters ≥2 in. (≥50 mm) and specified wall thicknesses of ⅛ to 1 1⁄16 in. (3 to 27 mm). When properly focused immersion search units are employed, this practice may also be applied to material of smaller diameter and thinner wall. When contact or immersion phased array search units are employed, this practice may also be applied to material of above-mentioned outside diameters and wall thicknesses.

NOTE 1—When contact or unfocused immersion search units are used, precautions should be exercised when examining pipes or tubes near the lower specified limits. Certain combinations of search unit size, frequency, thin–wall thicknesses, and small diameters could cause generation of unwanted sound waves that may produce erroneous examination results.

1.2 All surfaces of material to be examined in accordance with this practice shall be clean from scale, dirt, burrs, slag, spatter, or other conditions that would interfere with the examination results. The configuration of the weld must be such that interfering signals are not generated by reflections from it. Treatment of the inner surface and outer surface weld beads such as trimming ("scarfing") or rolling is often required to remove protuberances that could result in spurious reflections.

1.3 This practice does not establish acceptance criteria; they must be specified by the using parties.

1.4 *Units*—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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ASNT Documents:*[4]

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

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

2.3 *ISO Standard:*[5]

ISO 9712 Non-destructive Testing—Qualification and Certification of NDT Personnel

2.4 *AIA Standard:*[6]

NAS 410 Certification and Qualification of Nondestructive Testing Personnel

[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 ASME Boiler and Pressure Vessel Code applications, see related Practice SE-273 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, http://www.asnt.org.

[5] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

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

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

3. Terminology

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

4. Summary of Practice

4.1 A pulsed ultrasonic angle beam shall be propagated in the wall of the pipe or tube by either the surface contact or immersion method. Fig. 1 illustrates the characteristic oblique sound entry into the pipe wall for both contact and immersion examination from one search unit.

NOTE 2—The immersion examination method may include tanks, wheel search units, or bubbler systems.

4.2 The weld line shall be examined from both sides to ensure detection of imperfections with a shape or orientation that produces a preferential direction of reflection.

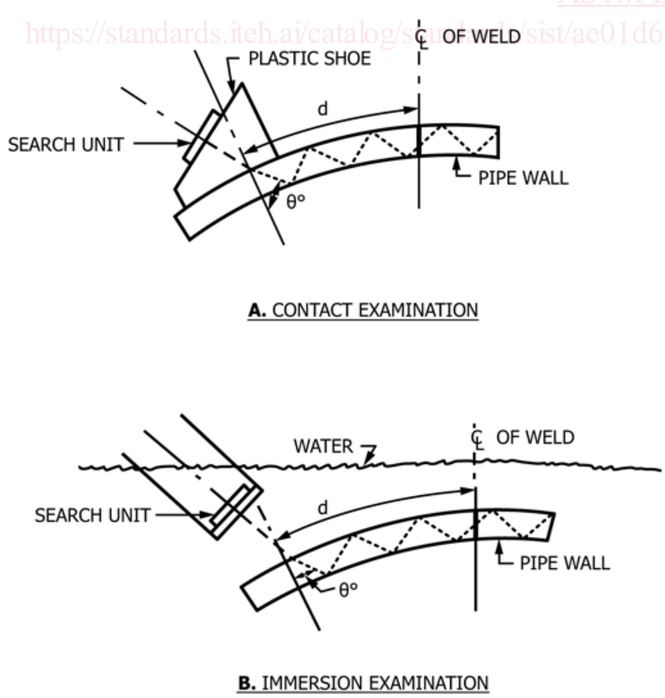
5. Significance and Use

5.1 The purpose of this practice is to outline a procedure for detecting weld discontinuities such as lack of fusion, pin holes, lack of penetration, longitudinal cracks, porosity and inclusions by the ultrasonic pulse-reflection method.

6. Basis of Application

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

6.2 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, ISO 9712, NAS 410, or a similar document and certified by the employer or certifying agency, as applicable.



NOTE 1—θ = 35° through 70°.

FIG. 1 Angle Projection of Ultrasonic Wave

The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

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

6.4 *Procedures and Techniques*—The procedures and techniques to be utilized shall be as specified in the contractual agreement, including:

6.4.1 Type, dimension, and number of reference reflectors to be placed in the reference standard,

6.4.2 Method(s) for measuring side versus side acoustic response of reference notches and tolerance limits,

6.4.3 Standardization of examination sensitivity intervals,

6.4.4 Examination frequency,

6.4.5 Pulse repetition rate,

6.4.6 Sound beam orientation and number of beams used,

6.4.7 Number of dead elements within a phased array virtual probe, and

6.4.8 Procedure and use of distance amplitude compensation.

6.5 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with 1.2 unless otherwise specified.

6.6 *Reporting Criteria/Acceptance Criteria*—Since acceptance criteria are not specified in this standard, they shall be specified in the contractual agreement.

6.7 *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. Procedure

7.1 *Apparatus*

7.1.1 The instruments and accessory equipment shall be capable of producing, receiving, amplifying, and displaying electrical pulses at frequencies and pulse rates deemed necessary by the using parties. They shall be capable of distinguishing the reference reflectors described in 7.2 to the extent required in the standardization procedure outlined in 7.3

7.1.2 For pulse echo examination systems, the contact or immersion search units should produce ultrasonic waves that travel in the pipe or tube wall at a refracted angle of from 35° to 70° and perpendicular to the weld seam. For pitch/catch or through transmission examination systems, orientation of the entry sound beam other than perpendicular to the weld seam may be required.

7.1.3 *Couplant*—A liquid such as water, oil, glycerin, etc., capable of conducting ultrasonic vibrations from the search unit to the pipe or tube 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 pipe or tubing and should wet the

surface. In examining electric-resistance-welded pipe, water-soluble oil used in cooling the pipe serves as a satisfactory couplant.

7.1.4 *Distance Amplitude Compensation*—The use of electronic methods to compensate for attenuation losses as a function of ultrasonic metal travel distance may be employed.

7.1.5 *Search Units*—The search unit must be appropriately sized with respect to width and beam included angle to achieve full wall thickness coverage.[7] Where this cannot be achieved with a single search unit propagating in a given direction, two or more search units may be used to scan in each direction. The effective beam length of the search units shall be such that reliable detection of all reference reflectors is accomplished without exceeding the "noise" limits of 7.3.2. The focal length of focused search units shall be at least equal to the radius of the material plus a suitable water path so that initial focus may be on the tube or pipe central axis.[8]

7.1.6 *Phased Array Transducers: Linear or Non-Linear Arrays*—Each virtual probe in the array shall meet the applicable requirements of a search unit as defined in 7.1.5. Virtual probe responses within an array shall be normalized to each other for a defined beam profile.

7.2 *Reference Standards*

7.2.1 A reference standard, of sufficient length to allow verification of system standardization, shall be prepared from a length of pipe or tubing of the same nominal diameter and wall thickness, material, surface finish, and acoustical properties as the material to be examined. The pipe or tube selected for this purpose shall be free of discontinuities or other abnormal conditions that can cause interference with the detection of the reference reflectors. The reference reflectors shall be selected to ensure uniform coverage of the weld at the sensitivity levels prescribed. The reference reflectors most commonly used will consist of machined notches and drilled holes as described in 7.2.2. All upset metal, burrs, etc., adjacent to the reference reflectors, shall be removed.

7.2.1.1 *Electric Resistance-Welded, Laser-Welded, or Butt-Welded Pipe*—Reference reflectors shall be placed in the center of weld seam and in a line parallel to it unless permission is obtained from the contracting or using agency to place the reference reflectors elsewhere in the reference standard. When longitudinal notches are used as reference reflectors, they shall be placed on the outer and inner surfaces of the reference standard and be separated by a sufficient distance to ensure that the response from one reflector does not interfere with that from the other.

NOTE 3—If reference reflectors are placed in a location other than the centerline of the weld seam, there is no assurance that the beam is penetrating the weld unless adequate signal response is obtained from the search units scanning the reflector from both sides of the weld. The lower amplitude of response from the two directions must be used in determining the rejection threshold level. Positioning of automatic alarm gates must be such as to respond to the signal from the reference reflector, but also the signals originating from the reflections from discontinuities anywhere in the weld seam itself.

7.2.1.2 *Fusion-Welded Pipe*—The reference reflectors shall be placed in the weld. When longitudinal notches are used as reference reflectors, they shall be placed in the crown of the fusion-weld bead as shown in Fig. 2(*a*). In fusion-welded pipe containing both inside and outside surface weld beads, a longitudinal notch reference reflector shall be placed in the weld-bead crown on both the outside and inside surfaces.

When drilled holes are employed, they shall be drilled radially from both the outside and inside surfaces through 50 % of the wall thickness at the weld-bead crown or such other depth as agreed upon by the user or contracting agency and separated by some distance that guarantees a distinct and separate response from each one (see Fig. 2(*c*) and Fig. 2(*d*)). By agreement between the purchaser and manufacturer, a hole drilled radially 100 % through the pipe wall may be used instead of the 50 % drilled hole (see Fig. 2(*e*)).

NOTE 4—Fill 50 % deep or through-holes with a waterproof filler such as bee's wax to prevent couplant entry. Otherwise, such entry could produce erratic or spurious reflections, or both.

Additional reflectors may be used to produce signals at reflection times that define weld-zone extremities for the purpose of establishing alarm gate timing or other means of controlling the examination area. Holes may be drilled radially 100 % through the pipe wall at the weld-zone edges.

7.2.2 The notch dimensions of length, depth, width, and for Fig. 3(*a*) and Fig. 3(*b*), the included angle α shall be decided upon by the using party or parties. Fig. 3 illustrates the commonly accepted notch configurations and the dimensions to be measured.

7.2.2.1 The notch depth (*h*) shall be measured from the adjacent surface to its maximum and minimum penetration. Measurements may be made by optical, replicating or mechanical, or other techniques. Notch depth is commonly

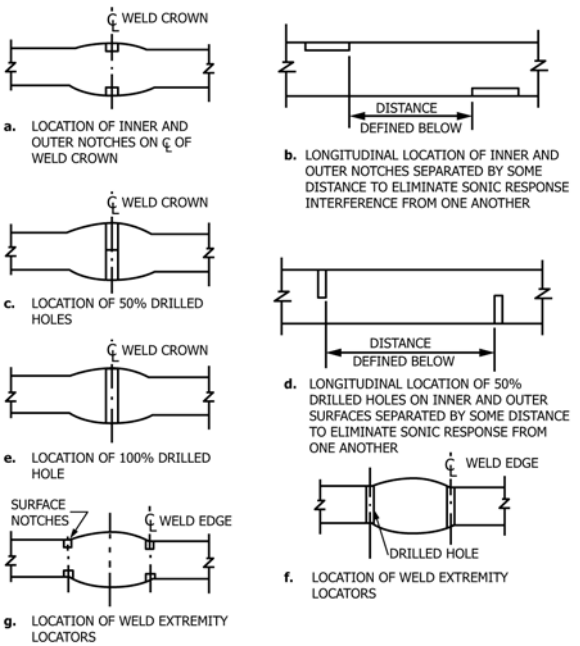


FIG. 2 Typical Notch Locations for Fusion Welded Pipe

[7] Beck, K. H., "Ultrasonic Refraction Angles for Inspection throughout the Total Wall Thickness of Tubes and Pipes," *Materials Evaluation,* Vol 51, No. 5, May 1993, pp. 607–612.

[8] Beck, K. H., "Ultrasonic Transducer Focusing for Inspection of Cylindrical Material," *Materials Evaluation,* Vol 59, No. 7, July 1991, pp. 875–882.