Designation: E273 – 15

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.

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 The values stated in inch-pound units are to be regarded as the standard. The SI equivalents are in parentheses and may be approximate.

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

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

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.

[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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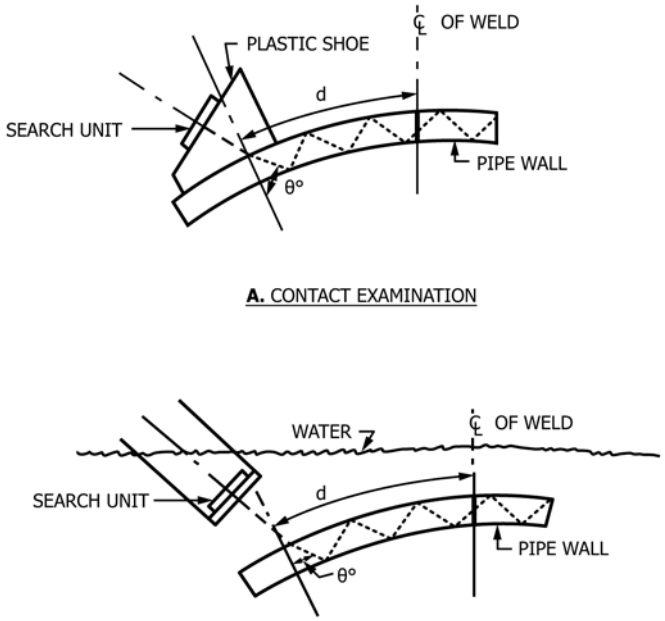
[2] For ASME Boiler and Pressure Vessel Code applications see related Practice SE-273 in Section II of that Code.

[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.

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



NOTE 1—θ = 35° through 70°.

FIG. 1 Angle Projection of Ultrasonic Wave

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. 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 E543. The applicable edition of 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 Standardization of examination sensitivity intervals,

6.4.3 Examination frequency,

6.4.4 Pulse repetition rate,

6.4.5 Sound beam orientation and number of beams used, and

6.4.6 Procedure and use of distance amplitude compensation.

6.5 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with paragraph 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 Section 7.2 to the extent required in the standardization procedure outlined in Section 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(**1**). Where this can not 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 (**2**).

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 paragraph 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 and/or spurious reflections.

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 specified as a percent of nominal wall thickness with typical values being 10, 12½, or 20 %. A +0/-10 % tolerance is allowable on notch depths.

7.2.2.2 The notch length (*l*) is considered to be the dimension over which the specified depth is maintained.

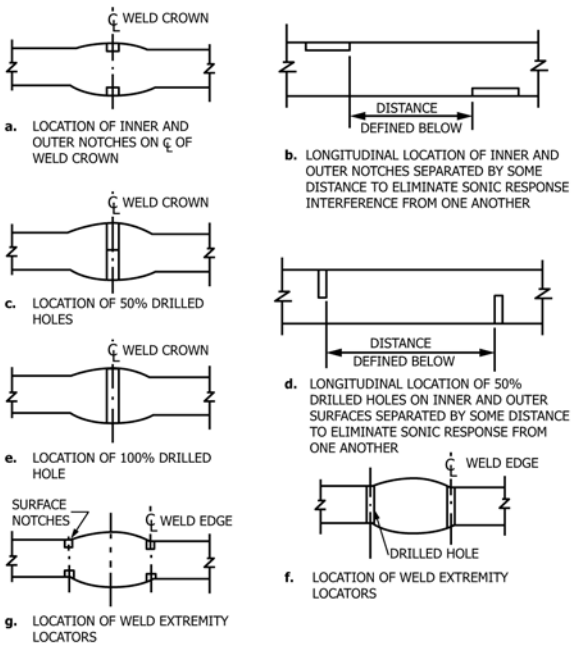


FIG. 2 Typical Notch Locations for Fusion Welded Pipe

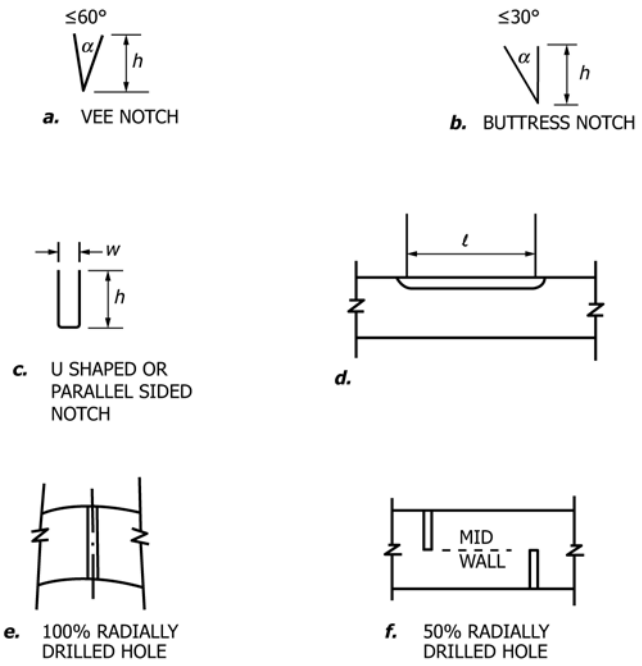


FIG. 3 Common Reference Reflectors

7.2.2.3 The width (*w*) of the notch has negligible effect on standardization and is not a critical dimension.

7.3 *Standardization of Examination Sensitivity*

7.3.1 Using the reference standard specified in 7.2, the equipment shall be adjusted to produce readily distinguished and clearly identifiable indications from both the inner and outer reference reflectors. The relative response to the inner and outer reflectors shall be as near equal as possible. The lesser of the two responses shall be used as the acceptance level.

NOTE 5—Adjustment of water path, adjustment of distance (*d*) in Fig. 1 and angulation of the beam are used to achieve equality. It should be noted however, that detection, or balancing of signals from both outer surface and inner surface notches does not guarantee that examination for radical defects is being achieved throughout the full wall thickness. To effect such examination, especially in pipes and tubes with thicker walls, it is necessary that the beam refraction angle and search unit size (beam included angle for focused units) be selected to be compatible with the ration of diameter-to-wall-thickness of the material as stated in 7.1.5 and described in Reference **(1)**.

7.3.2 Instrument sensitivity and scanning system parameters, such as search unit positioning and scanning, speed, shall be adjusted to produce signal levels that are repeatable from all reference indicators within the limits described below. If a strip chart or similar recorder is used, the amplitude stability of all target indications shall be within 10 % of full scale height (FSH) for several successive scans of the reference standard under conditions simulating those that will be used for the actual material examination. Peak "noise" signal amplitudes observed during scanning over a length of the reference standard equal to at least twice the distance between outer surface and inner surface notches, shall not exceed 40 % of the minimum amplitude of the signals from the reference indicators. If only an audible or other alarm device is used to indicate the presence of rejectable indications, such devices shall be actuated reliably by all reference indicators for several successive scans of the reference standard under conditions simulating those that will be used for the actual material examination.

7.3.3 When weld edge reflectors are used, the equipment shall be adjusted to produce clearly identifiable responses from them that are distinguishable from the reference reflectors used to set rejection limits when the reference standard is scanned in a manner simulating the production examination of the pipe or tubing.

7.3.4 During the standardization procedure, the extent of variation in the dimension (d) (that is, the amount of weld line skew with respect to the search units) that can be tolerated without exceeding the stability limits of 7.3.2 shall be determined and provisions made in the scanning system to ensure that the positions of the search units relative to the weld line are maintained within that limit.

7.4 *Examination Procedure*

7.4.1 Move the pipe or tubing past the search unit with the weld in a fixed position with respect to the search unit. Movement of the search unit with respect to a stationary pipe is satisfactory. During examination, maintain distance (*d*) and angle θ in Fig. 1 and the water path for immersion examination as determined during adjustment of the examination sensitivity. Depending upon the degree of crookedness of the material to be examined, maintenance of these parameters may require the use of "followers" or other devices to enable a stable scan pattern to be maintained.

7.4.2 Certain examination systems using multiple search units or multiple beam transducers compensate for distance (*d*) changes and do not require strict adherence to the maintenance of this dimension during examination. With whatever arrangement is used, the allowable amount of weld line skew shall be determined as in 7.3.4 and scanning provisions made to prevent that limit from being exceeded.

7.4.3 Periodically check the examination sensitivity of the equipment by running the reference standard through the examination system. Make these checks prior to any pipe or tubing examination, prior to equipment shutdown after examination and at least every four hours during continuous equipment operation. Anytime the equipment does not present a clearly defined signal within 10 % of that obtained when the examination sensitivity was established, restandardize the equipment in accordance with Section 7.2.

7.4.4 In the event that the equipment presents a signal more than 10 % below the standardization level, reexamine, when standardization has been accomplished, all pipe and tubing examined subsequent to the last preceding acceptable standardization.

8. Interpretation of Results

8.1 All indications that are equal to or greater than the reference signals established during standardization as described in Section 7.3, or as specified in Section 6, shall be considered as representing defects that may be cause for rejection of the pipe or tube.

8.2 If upon examination of the pipe or tube, no rejectable indications are detected, the material shall be considered as having passed the ultrasonic examination, except as noted in 7.4.4.

9. Keywords

9.1 angle beam; longitudinal welded pipe; longitudinal welded tubing; nondestructive examination; ultrasonic examination

REFERENCES

(1) 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.

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

SUMMARY OF CHANGES

Committee E07 has identified the location of selected changes to this standard since the last issue (E273-10) that may impact the use of this standard.

(1) Added references included in 6.2 to Section 2.
(2) Modified Section 6 to incorporate appropriate language from E07 Policy P10.
(3) Modified previous Sections 7–10 to create current Section 7, to comply with formatting as provided in Section C of the Form and Style Guide.
(4) Added new Section 5, Significance and Use.