Designation: E 273 – 93

An American National Standard

# Standard Practice for Ultrasonic Examination of Longitudinal Welded Pipe and Tubing[1]

This standard is issued under the fixed designation E 273; 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 Department of Defense.*

## 1. Scope

1.1 This practice[2] describes general ultrasonic test procedures for the detection of discontinuities in the weld and adjacent heat affected zones of pipe and tubing. It is intended for tubular products having diameters ≥2 in. (≥50 mm) and wall thicknesses of ⅛ to 1 1⁄16 in. (3 to 27 mm).

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

NOTE 1—Precautions should be exercised when testing 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 test results.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety problems, 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:*

E 543 Practice for Evaluating Agencies that Perform Nondestructive Testing[3]

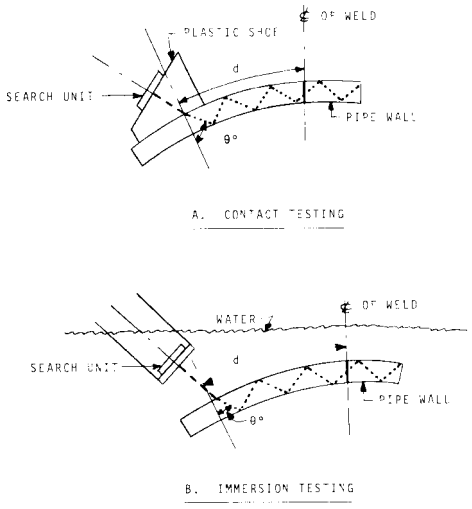
E 1316 Terminology for Nondestructive Examinations[3]

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E 1316.

## 4. Summary of Practice

4.1 Angle projection of pulsed ultrasonic beam by either the surface contact or immersion method shall be used. Fig. 1 illustrates the characteristic oblique sound entry into the pipe wall for both contact and immersion testing using a single search unit.




NOTE 1—θ = 35° through 70°.

**FIG. 1 Angle Projection of Ultrasonic Wave**

NOTE 2—Immersion test method may include tanks, wheel search units, or bubbler systems.

4.2 Variations of the single search unit method using multiple search units with the same or various angles and special gating are sometimes desirable and may be necessary for efficient examination of thicker wall material.

## 5. Apparatus

5.1 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 to the extent required in the calibration procedure outlined in Section 8.

5.2 For pulse echo test 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 test systems, orientation of the entry sound beam other than perpendicular to the weld seam may be required.

5.3 *Couplant*—A liquid such as water, oil, glycerin, etc.,

[1] This practice is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Method.

Current edition approved Sept. 15, 1993. Published November 1993. Originally published as E 273 – 65 T. Last previous edition E 273 – 83 (1989).

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

[3] *Annual Book of ASTM Standards*, Vol 03.03.

capable of conducting ultrasonic vibrations from the transducer 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 the testing of electric-resistance-welded pipe, water-soluble oil used in cooling the pipe serves as a satisfactory couplant.

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

## 6. Basis of Application

6.1 The following are items that require decision for use of this practice:

6.1.1 Acceptance criteria,

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

6.1.3 Standardization of test sensitivity intervals,

6.1.4 Operator qualifications,

6.1.5 Qualification of NDT agency (as defined in Practice E 543), if required. Practice E 543 may be used for this agency qualification.

6.1.6 Test frequency,

6.1.7 Pulse repetition rate,

6.1.8 Sound beam orientation and number of beams used,

6.1.9 Procedure and use of distance amplitude compensation, and

6.1.10 Reporting of test results.

## 7. Personnel Qualification

7.1 The ultrasonic examination shall be performed by qualified personnel. Qualification shall be based on a documented program that certifies personnel capable of conducting ultrasonic weld examinations.

## 8. Reference Standards

8.1 A reference standard, of sufficient length to allow verification of system calibration, shall be prepared from a length of pipe or tubing of the same nominal diameter and wall thickness, material, surface finish, and nominal heat treatment 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 8.2. All upset metal, burrs, etc., adjacent to the reference reflectors, shall be removed.

8.1.1 *Electric Resistance-Welded or Butt-Welded Pipe*—Reference reflectors may be placed in the weld seam or in the pipe body and parallel to the weld seam. When longitudinal notches are used as reference reflectors, they shall be placed on the outer and inner surfaces of the reference standard and separated by some distance to ensure that the response from one reflector does not interfere with that from the other.

8.1.2 *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.

8.1.2.1 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 and separated by some distance that guarantees a distinct and separate response from each one (see Fig. 2(*c*) and Fig. 2(*d*)). A hole drilled radially 100 % through the pipe wall may be used instead of the 50 % drilled hole (see Fig. 2(*e*)).

8.1.2.2 Additional reflectors may be used to define weld extremities. Holes shall be drilled radially 100 % through the pipe wall at the weld edges. As an alternative, longitudinal notches shall be placed at the edges of each weld (see Fig. 2(*f*)). The weld-edge drilled holes or notches shall be separated by some distance to ensure that the response from one reflector does not interfere with that from another (see Fig. 2(*g*)). The weld-edge reflectors are solely for the purpose of defining the position of the weld extremities and are not to be used for amplitude standardization.

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

8.2.1 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 ±15 % tolerance is allowable on notch depths.

8.2.2 The length of the notch is considered to be the dimension where the depth of 8.2.1 is satisfied. It is preferred

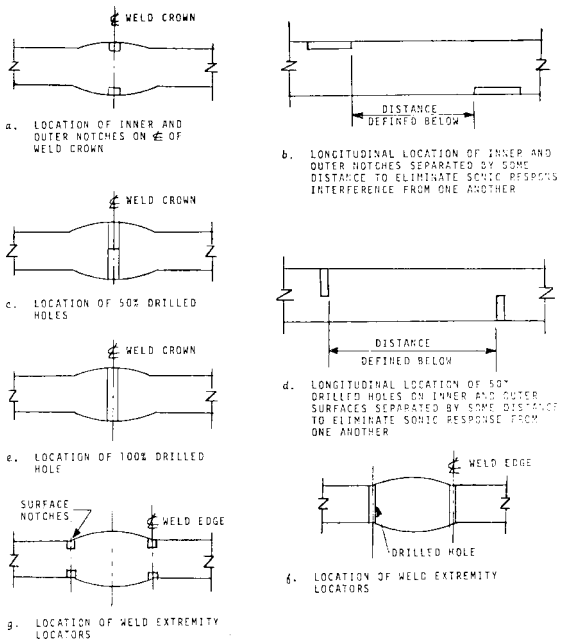



**FIG. 2 Typical Notch Locations for Fusion Welded Pipe**

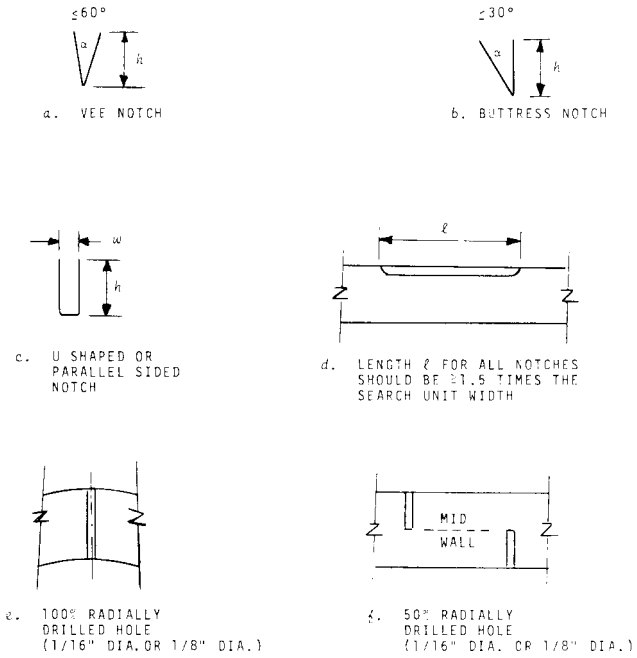



**FIG. 3 Common Reference Reflectors**

that the notch length (*1*) be ≥1.5 times the transducer element size.

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

8.2.4 Typical diameters for drilled holes are 1⁄16 in. (1.6 mm) and 1⁄8 in. (3.2 mm).

## 9. Standardization of Test Sensitivity

9.1 Using the reference standard specified in 8.1, 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 3—Adjustment of water path, adjustment of distance (*d*) in Fig. 1 and angulation of the beam have been used to achieve equality.

9.2 The test sensitivity shall be standardized and adjusted to produce clearly identifiable indications from both the outer and inner reference reflectors when the reference standard is scanned in a manner simulating the production examination of the pipe or tubing.

9.3 The equipment shall be adjusted to produce clearly identifiable responses from the weld-edge reflector and the reference reflector when the reference standard is scanned in a manner simulating the production examination of the pipe or tubing.

## 10. Examination Procedure

10.1 All surfaces shall be clean from scale, dirt, burrs, slag, spatter, or other conditions that will interfere with the test results.

10.2 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 testing as determined during adjustment of the test sensitivity.

10.3 Certain testing 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.

10.4 Periodically check the test 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 test sensitivity was established, readjust the equipment in accordance with Section 8.

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

## 11. Interpretation of Results

11.1 All indications that are equal to or greater than the reference signals established during standardization as described in Section 9, or as specified in Section 6, shall be considered as representing defects that may be cause for rejection of the pipe or tube.

11.2 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 10.5.

## 12. Keywords

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