INTERNATIONAL

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Standard Practice for Conventional Pulse-Echo Ultrasonic Testing of Polyethylene Electrofusion Joints[1]

This standard is issued under the fixed designation E3167/E3167M; 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 a procedure for ultrasonic testing (UT) of electrofusion joints in polyethylene pipe systems. This practice provides one ultrasonic examination procedure for ultrasonic pulse-echo straight beam contact testing, using straight-beam longitudinal waves introduced by direct contact of the search unit with the material being examined.

1.2 The practice is intended to be used on polyethylene electrofusion socket (for example, couplings) and saddle (for example, tees) fittings for use on polyethylene pipe ranging in diameters from nominal 0.5 in. to 12 in. [12 mm to 300 mm] with pipe dimension ratios (DR) ranging from 6.3 to 17. Greater and lesser thicknesses and greater and lesser diameters may be tested using this practice if the technique can be demonstrated to provide adequate detection on mockups of the same wall thickness and geometry.

1.3 This practice does not address ultrasonic examination of butt fusions. Ultrasonic testing of polyethylene butt fusion joints is addressed in Practice E3044/E3044M.

NOTE 1—The notes in this practice are for information only and shall not be considered part of this practice.

NOTE 2—This standard references HDPE and MDPE materials for pipe applications defined by Specification D3350.

1.4 This practice does not specify acceptance criteria. Refer to Specification F1055 and Practice F1290 for destructive acceptance criteria.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.7 *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 The following documents form a part of this practice to the extent specified herein.

2.2 *ASTM Standards:*[2]

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
E114 Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing
E543 Specification for Agencies Performing Nondestructive Testing
E1316 Terminology for Nondestructive Examinations
E3044/E3044M Practice for Ultrasonic Testing of Polyethylene Butt Fusion Joints
F412 Terminology Relating to Plastic Piping Systems
F1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
F1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings

2.3 *ASNT Standards:*[3]

ASNT Practice SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing
ANSI/ASNT-CP-189 Standard for Qualification and Certification 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 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.

[3] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

2.4 *AIA Document:*[4]

NAS 410 Certification and Qualification of Nondestructive Testing Personnel

2.5 *ISO Standard:*[5]

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

3. Terminology

3.1 *Definitions*—Related terminology is defined in Terminology E1316 and Terminology F412.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cell classification, n*—for polyethylene pipe resin, this is a six-digit code and letter describing the primary properties that are considered important in the manufacture of PE piping, in the heat fusion joining of this material, and in defining the long-term performance capabilities and color/UV stability. The classification categories are defined in Specification D3350.

3.2.2 *dimension ratio (DR), n*—the average specified outside pipe diameter divided by the minimum specified wall thickness.

3.2.2.1 *Discussion*—The wall thickness increases when the DR decreases.

3.2.2.2 *Discussion*—Standard Dimension Ratio (SDR) is an ANSI term to describe specific DRs in the series, for example SDR9, SDR11, SDR17, and others.

3.2.3 *electrofusion joint, n*—a joint made by using an electrofusion type fitting where a heat source is an integral part of the fitting. The pipe is inserted into the socket of the fitting or the saddle of the fitting is placed over the pipe. When an electric current is applied, heat is produced that melts the plastic of both the fitting and pipe resulting in a continuous joint between the fitting and the pipe. It is recommended that the fusion procedures comply with Practice F1290 and fittings to Specification F1055.

3.2.4 *high density polyethylene (HDPE), n*—a tough, flexible, thermoplastic resin made by polymerizing ethylene, having a density range of >0.940 g/cm^3 to 0.955 g/cm^3 in accordance with Specification D3350.

3.2.5 *material designations, n*—a shortened code to identify the pipe material's short-term and long-term properties.

3.2.5.1 *Discussion*—For polyethylene, the "PE-XXXX" material designation represents the density (first digit), slow crack growth resistance (second digit) and hydrostatic design stress (HDS, last two digits) where Specification D3350 is the reference.

3.2.6 *medium density polyethylene (MDPE), n*—a tough, flexible, thermoplastic resin made by polymerizing ethylene, having density range of >0.925 g/cm^3 to 0.940 g/cm^3 in accordance with Specification D3350.

3.2.7 *particulate contamination, n*—fine particles, such as airborne dust, or coarse particles, such as sand and grit, that are present at the fusion interface.

4. Summary of Practice

4.1 This practice provides a general description of the procedures to carry out ultrasonic examination of polyethylene electrofusion joints in pipeline systems.

4.2 This practice uses sound waves to examine electrofusion joints made of polyethylene in order to identify and size internal fusion joint flaws with the intent to non-destructively assess overall joint quality.

4.3 This practice has principles common to those found in Practice E114 where pulse-echo straight-beam contact testing is described.

4.4 This practice recommends the use of properly fused joints as a reference aid to identify flaws.

4.5 Examination results using this practice may be used in combination with acceptance criteria based on workmanship or fitness for purpose.

5. Significance and Use

5.1 This practice is intended primarily for the manual ultrasonic scanning of electrofusion joints used in the construction and maintenance of polyethylene piping systems.

5.2 Polyethylene piping has been used instead of steel alloys in the petrochemical, power, water, gas distribution, and mining industries due to its reliability and resistance to corrosion and erosion.

5.3 This practice is not intended to provide 100 % joint examination. This practice specifies a minimum scanning grid that represents only a portion of the welded interface. As such, there exists a possibility of omitting flaws. In addition, selected areas of the welded interface may not be accessible. The extent of examination shall be specified in the contractual agreement.

5.4 The joining process can be subject to a variety of flaws including, but not limited to, lack of fusion, particulate contamination, short-stab depth, inclusions, and voids.

5.5 Polyethylene material can have a range of acoustic characteristics that make electrofusion joint examination difficult. Polyethylene materials are highly attenuative, which often limits the use of higher ultrasonic frequencies. It also exhibits a natural high frequency filtering effect. An example of the range of acoustic characteristics is provided in Table 1.[6] The table notes the wide range of acoustic velocities reported in the literature. This makes it essential that the reference blocks are made from pipes with the same Specification D3350 density cell classification as the electrofusion fitting examined.

5.6 Polyethylene is reported to have a shear velocity of 987 m/s. However, due to extremely high attenuation in shear mode (on the order of 5 dB/mm [127 dB/inch] at 2 MHz) no practical examinations can be carried out using shear mode (**6**).

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

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[6] The boldface numbers in parentheses refer to a list of references at the end of this standard.

TABLE 1 Polyethylene Velocity and Attenuation[A]

Compression Mode Velocity m/s [in./µs]	Attenuation at 2 MHz dB/mm [dB/in.]	Attenuation at 5 MHz dB/mm [dB/in.]
2100 to 2670 [0.082 to 0.105]	0.6 to 1.5 [15.2 to 38]	1.1 to 2.3 [27.9 to 58]

[A] A range of velocity and attenuation values have been noted in the literature **(1-9)**.

5.7 Due to the wide range of applications, joint acceptance criteria for polyethylene pipe are usually project-specific.

5.8 A cross-sectional view of typical electrofusion joints between polyethylene pipe and coupling and between pipe and saddle are illustrated in Fig. 1 and Fig. 2, respectively.

6. Basis of Application

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

6.2 *Personnel Qualification*—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, ISO 9712, 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 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 used shall be as specified in the contractual agreement. If required, performance demonstrations shall be carried out on electrofusion joints containing all of the flaw types (for example, lack of fusion, particulate contamination, short stab depth, etc.) that are required to be detected in the contractual agreement.

6.5 *Surface Preparation*—The pre-examination surface preparation shall be in accordance with Section 7 unless otherwise specified.

6.6 *Timing of Examination*—The timing of the examination shall be in accordance with Section 7 unless otherwise specified.

6.7 *Extent of Examination*—The extent of examination shall include the surface grid area as defined in Section 7, as a minimum, unless otherwise specified in the contract.

6.8 *Reporting Criteria*—Reporting criteria for the examination results shall be in accordance with Section 8 unless otherwise specified. Since acceptance criteria are not specified in this standard, they shall be specified in the contractual agreement.

6.9 *Re-examination of Repaired/Reworked Items*—Re-examination of repaired/reworked items is not addressed in this standard and if required shall be specified in the contractual agreement.

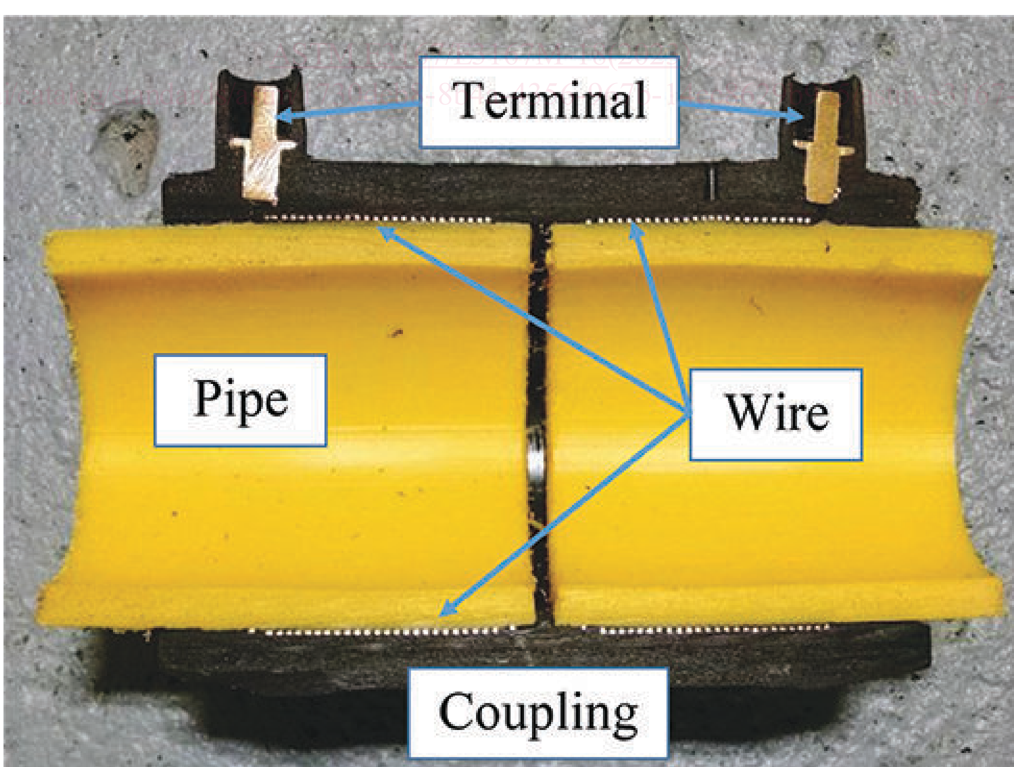

FIG. 1 Typical Cross-Sectional View of an Electrofusion Coupling Joint

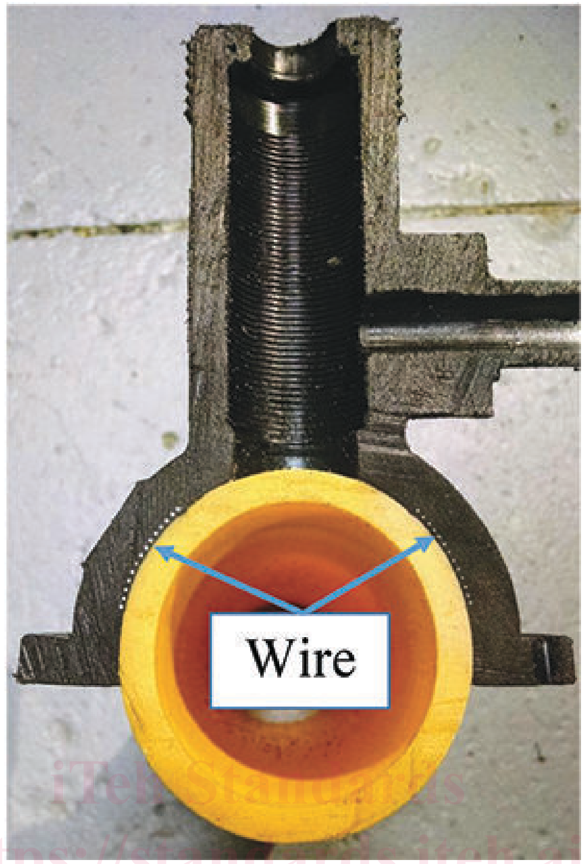

FIG. 2 Typical Cross-Sectional View of an Electrofusion Saddle Tee Joint

7. Apparatus and Procedures

7.1 *Electronic Instruments and Search Units*—The type of instrument(s) used for the examinations specified in Section 7 shall conform to the applicable requirements of Practice E114.

7.1.1 Search units shall produce pulses with a nominal center frequency in the range of 1 MHz to 10 MHz. The search unit diameter and frequency should be selected such that the fusion interface lies in the far-field and the diameter shall be selected to allow multiple measurements over the fusion interface as required by 7.6.

NOTE 3—In some cases, due to the fusion interface depth and the limitation of available search units, the interface depth may occur in the near-field. In such cases, sizing of indications will be less reliable.

NOTE 4—For saddles, the fusion interface may be partially obstructed by the saddle outlet. The search unit diameter should be selected such that it is smaller than the accessible fusion mat width. Multiple rows may be possible with suitably sized searched units.

7.1.2 Wedges of the hard-plastic variety shall be contoured to match the surface of the fitting when the gap between the search unit and the scanned surface exceeds 0.5 mm (0.02 in.). Table 2 provides recommendations on probe sizes to avoid significant gaps.

7.2 *Standardization Blocks:*

7.2.1 *Reference Blocks for Standardization*—Ultrasonic reference blocks are used to standardize the ultrasonic equipment. Examples of reference block designs are provided in Annex A1. The ultrasonic characteristics of the reference blocks, such as attenuation, noise level, and sound velocity, shall be similar to the material to be examined in accordance with A1.2. Standardization verifies that the instrument and search unit are performing as required and sets a sensitivity level. The temperature of the reference blocks shall be within ±10 °C [±18 °F] of the surface of the electrofusion fitting at the time of examination.

NOTE 5—Environmental conditions at the time of examination may result in some areas of the pipe surface being significantly warmer than others (for example, exposed to sun versus in shade) if unshaded. This may require provision of shade, time for temperature equilibration, and standardization at different temperatures.

7.2.2 *Alternative Reference Blocks*—The molded-in fusion heating wire in an electrofusion fitting of the same geometry as the fitting to be examined may be used as targets to establish gain. A properly fabricated electrofusion joint using the same fitting (type, manufacturer, material, size) and similar type of pipe (material, size, DR) of the joint that is to be examined can

TABLE 2 Recommended Probe Sizing

Nominal Search Unit Outer Diameter, mm [inch]	Minimum Fitting Size (IPS)
6 [0.25]	≥1/2
10 [0.375]	≥1/2
12 [0.5]	≥1
20 [0.75]	≥3
25 [1]	≥6
32 [1.25]	≥10