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Standard Practice for Phased Array Ultrasonic Testing of Polyethylene Electrofusion Joints[1]

This standard is issued under the fixed designation E3170/E3170M; 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 covers procedures for phased array ultrasonic testing (PAUT) of electrofusion joints in polyethylene pipe systems. Although high density polyethylene (HDPE) and medium density polyethylene (MDPE) materials are most commonly used, the procedures described may apply to other types of polyethylene.

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 for pipe applications defined by Specification D3350.

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

1.3 Phased array ultrasonic testing (PAUT) of polyethylene electrofusion joints uses longitudinal waves introduced by an array probe mounted on a zero degree wedge. This practice is intended to be used on polyethylene electrofusion couplings for use on polyethylene pipe ranging in diameters from nominal 4 in. to 28 in. (100 mm to 710 mm) and for coupling wall thicknesses from 0.3 in. to 2 in. (8 mm to 50 mm). Greater and lesser thicknesses and diameters may be tested using this standard practice if the technique can be demonstrated to provide adequate detection on mockups of the same geometry.

1.4 This practice does not specify 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

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

E2700 Practice for Contact Ultrasonic Testing of Welds Using Phased Arrays

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 Documents:*[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]
NAS410 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 *cold fusion, n*—a joint or a region within a joint in which there is little commingling of the polymer chains due to reasons other than contamination.

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

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

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

3.2.4 *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 polyethylene 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.

3.2.5 *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.

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

3.2.6.1 *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.

3.2.7 *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.

3.2.8 *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 phased array ultrasonic examination of polyethylene electrofusion joints in pipeline systems.

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

4.3 The procedure described in this practice has principles common to those found in Practice E2700, where phased array contact testing is described.

4.4 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 for the semi-automated or automated ultrasonic examination 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 The joining process can be subject to a variety of flaws including, but not limited to: lack of fusion, cold fusion, particulate contamination, inclusions, short stab depth, and voids.

5.4 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]

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)**.

The table notes the wide range of acoustic velocities reported in the literature. This makes it essential that the reference blocks are made from pipe grade polyethylene with the same density cell class as the electrofusion fitting examined.

[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.

5.5 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 ⁄in.) at 2 MHz) no practical examinations can be carried out using shear mode (**6**).

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

5.7 A cross-sectional view of a typical joint between polyethylene pipe and an electrofusion coupling is illustrated in Fig. 1.

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, NAS410, 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, cold fusion, 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 7.4 unless otherwise specified.

6.6 *Timing of Examination*—The timing of the examination shall be in accordance with 7.5 unless otherwise specified.

6.7 *Extent of Examination*—The extent of examination in the axial direction shall include, as a minimum, the nominal length of each fusion zone and in the circumferential direction should include the full circumference. Areas not tested due to obstructions, such as connectors and melt indicators, shall be reported.

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.

7. Apparatus and Procedures

7.1 *Electronic Instruments and Probes:*

7.1.1 The type of instrument(s) used for the examinations specified in Section 7 shall conform to the applicable requirements of Practice E2700.

7.1.2 Probes used shall produce pulses with a nominal center frequency in the range of 1 MHz to 10 MHz.

7.1.3 Wedges of the hard plastic variety shall be contoured to match the surface of the fitting when the gap between the wedge and fitting exceeds 0.5 mm (0.02 in.).

7.2 *Standardization Blocks and Other Equipment:*

7.2.1 *Mechanics:*

7.2.1.1 Mechanical holders shall be used to ensure that the axial and radial position of the probe is maintained at a fixed distance from the fusion zone.

7.2.1.2 Probe motion may be achieved using motorized or manual means, but in all cases, the mechanical holder for the probes shall be equipped with a positional encoder that is synchronized with the sampling of A-scans. Data acquisition shall not exceed 1 mm (0.04 in.) per A-scan sample for pipe diameters up to 500 mm (20 in.) and shall not exceed 2 mm (0.08 in.) per A-scan sample for pipe diameters greater than 500 mm (20 in.).

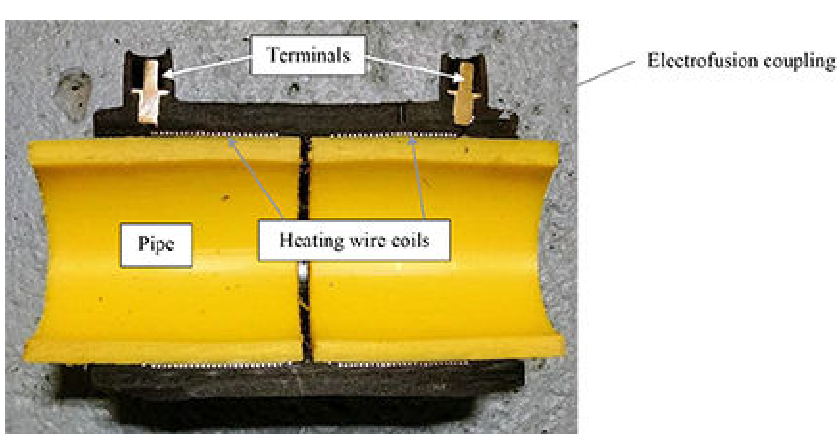

FIG. 1 Typical Cross-Sectional View of an Electrofusion Coupling Joint