Designation: E3044/E3044M – 22

Standard Practice for Ultrasonic Testing of Polyethylene Butt Fusion Joints[1]

This standard is issued under the fixed designation E3044/E3044M; 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 procedures for ultrasonic testing (UT) of butt fusion joints in polyethylene pipe. 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 specification.

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

1.2 This practice does not address ultrasonic examination of electrofusion joints (coupling joints), socket joints, or saddles.

1.3 This practice provides two ultrasonic examination procedures. Each has its own merits and requirements for examination and shall be selected as agreed upon in a contractual document.

1.3.1 *Examination Procedure A, Time of Flight Diffraction (TOFD),* uses a pair of probes, one transmitting and the other receiving. The procedure usually, although not necessarily, requires access to both sides of the joint from one surface. Provided that position encoding is used, the procedure can be conducted by semi-automated or automated means that provide recoded imaging.

1.3.2 *Examination Procedure B, Phased Array Ultrasonic Testing (PAUT),* uses low velocity refracting wedges or water gaps to produce angled compression mode pulses. The procedure can be applied where access is limited to one side of the joint from one surface. Provided that position encoding is used, the procedure can be conducted by semi-automated or automated means that provide recoded imaging.

1.4 The practice is intended to be used on thicknesses of 9 to 60 mm [0.375 to 2.4 in.] and diameters 100 mm [4 in.] and greater. Greater and lesser thicknesses and lesser diameters may be tested using this standard practice if the technique can be demonstrated to provide adequate detection on mockups of the same wall thickness and geometry.

1.5 This practice does not specify acceptance criteria.

1.6 *Units*—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.

1.7 *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.*

1.8 *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

E494 Practice for Measuring Ultrasonic Velocity in Materials by Comparative Pulse-Echo Method

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

E2373 Practice for Use of the Ultrasonic Time of Flight Diffraction (TOFD) Technique

E2700 Practice for Contact Ultrasonic Testing of Welds Using Phased Arrays

F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

2.3 *ASNT Standards:*[3]

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

[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.

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

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

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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *butt-fusion joint, n*—a joint made by holding the prepared squared ends of two pipes or pipe and fitting against a heated plate per the conditions of a qualified fusion procedure, which allows for the ends to be brought together after forming the proper melt, and then allowing the joint to cool while maintaining the appropriate applied force. It is recommended that fusion procedures comply with Practice F2620.

3.2.2 *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, in defining the long-term performance capabilities and color/UV stability. The classification categories are defined in Specification D3350.

3.2.3 *dimension ratio (DR), n*—this is the average outside pipe diameter divided by the minimum 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, DR9, DR11, DR17, and others.

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 per Specification D3350.

3.2.5 *material designations, n*—a shortened code to identify the pipe materials 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 >0.926 g/cm^3 to 0.940 g/cm^3 per Specification D3350.

4. Summary of Practice

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

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

4.3 Two procedures are described in this practice that have principles common to those found in Practices E2373 and E2700 where Time of Flight Diffraction and Phased-Array contact testing are 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 primarily for the automated or semi-automated ultrasonic examination of butt fusion joints used in the construction of polyethylene piping systems.

5.2 Polyethylene piping has been used in lieu of steel alloys in the petrochemical, power, water, gas distribution and mining industries due to its reliability and resistance to corrosion and erosion. Recently, polyethylene pipe has also been used for nuclear safety-related cooling water applications.

5.3 Two ultrasonic techniques have proven useful to provide examination of fusion joint integrity; Ultrasonic time-of-flight-diffraction (TOFD) and phased array ultrasonic testing (PAUT). These techniques are often considered complementary but may be used independently of each other. The choice of the technique used may depend on a variety of parameters including diameter, thickness, surface access, detection capabilities near surfaces, and quality level required.

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

5.5 Polyethylene material can have a range of acoustic characteristics that make butt joint examination difficult. Acoustic velocity of the material is similar to that commonly used for ultrasound wedge materials, making it difficult to use these materials to achieve appropriate refraction of sound at the interface. 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. The table notes the wide range of acoustic velocities reported in the literature. This makes it essential that the reference blocks are

TABLE 1 Polyethylene Velocity and Attenuation[A]

Compression Mode Velocity (m/s) [in./µs]	Attenuation @2 MHz (dB/mm) [dB/in.]	Attenuation @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 boldface numbers in parentheses refer to the list of references at the end of this standard.

[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.