Designation: E3102 − 18

Standard Practice for Microwave Examination of Polyethylene Electrofusion Joints Used in Piping Application[1]

This standard is issued under the fixed designation E3102; 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 microwave (MW) examination of electrofusion joints made entirely of polyethylene for the purpose of joining polyethylene piping.

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

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

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

1.3 The practice is intended to be used on joint thicknesses of 0.5 in. to 4 in. (12 mm to 100 mm) and diameters 4 in. (100 mm) 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.

1.4 This practice can be applied to post assembly inspection of polyethylene electrofusion joints.

1.5 This practice does not specify acceptance criteria.

1.6 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 *ASTM Standards:*[2]

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ASNT Documents:*[3]

Recommended Practice SNT-TC-1A for Nondestructive Testing Personnel Qualification and Certification

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

2.3 *Military Standard:*[4]

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification

2.4 *AIA Document:*[5]

NAS 410 Certification and Qualification of Nondestructive Testing Personnel

2.5 *Welding Authority Document:*[6]

DVS Direction 2202-1 Imperfections in Thermoplastic Welded Joints; Features, Descriptions, Evaluation

2.6 *ISO Standard:*[7]

ISO 9712 Non-destructive Testing – Qualification and Certification of NDT Personnel

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 Related terms are defined in Terminology E1316.

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[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.10 on Specialized NDT Methods.

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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.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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

[6] Available from IHS, 15 Inverness Way East, Englewood, CO 80112, http://www.global.ihs.com.

[7] 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.

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

3.1.3 *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.

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

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

3.1.4.2 *Discussion*—Standard Dimension Ratio (SDR) is an ANSI term to describe specific DRs in the series, that is, DR9, DR11, DR17, and others.

3.1.5 *E plane, n—in the case of a linearly polarized microwave probe*, this is the plane that contains the electric field and is at a right angle to the H plane.

3.1.6 *electrofusion joining, n*—the joining of two polyethylene pipe ends using an electrofusion coupling that has a heat source as an integral part of the design such as electrical wires. When a current is induced into wires, these produce heat and melt the surrounding surfaces of the pipe and coupling. The melted material from the two components flow together and fuse to make the joint.

3.1.7 *H plane, n—in the case of a linearly polarized microwave probe*, this is the plane that contains the magnetic field, and it is at a right angle to the E plane.

3.1.8 *high density polyethylene (HDPE), n*—a tough, flexible, thermoplastic resin made by polymerizing ethylene, having a density range of >0.940 g/cm^3 – 0.965 g/cm^3 per Specification D3350.

3.1.9 *index, n*—the movement of the probe in the circumferential direction at the completion of a scan line, typically in small increments, to position the probe to the start of the next scan.

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

3.1.10.1 *Discussion*—For polyethylene, the "PE-XXXX" format represents the density (1st digit), slow crack growth resistance (2nd digit), and Hydrostatic Design Stress (HDS, last two digits) where Specification D3350 is the reference.

3.1.11 *medium density polyethylene (MDPE), n*—a tough, flexible, thermoplastic resin made by polymerizing ethylene, having a density range of >0.926 g/cm^3 – 0.940 g/cm^3 per Specification D3350.

3.1.12 *MW transducer, n*—an electronic device that generates an electromagnetic field in the microwave frequency range (1 – 100 GHz) and is equipped with at least one microwave detector that converts the microwave energy into voltage.

3.1.13 *probe, n*—a MW transducer and a waveguide or other MW antenna enclosed in a fabricated container used specifically for MW inspection.

3.1.14 *scan, n*—the movement of the probe in a straight line, usually along the long axis of the part being examined, where data is collected.

3.1.15 *standoff, n*—the distance between the outside surface of the joint to be examined and the end of the MW probe that is adjustable to provide proper examination of the joint.

4. Summary of Practice

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

4.2 This practice consists of bathing the electrofusion joint in a field of magnetic radiation at a specific frequency (or range of frequencies) in the microwave range using a MW Probe. This probe is passed over the electrofusion joint in a controlled technique using a specified scan and index pattern until the entire part or the region of interest has been completely covered. The reflected microwave energy is measured by the transducer along the scan lines, and the resulting transducer voltage is recorded along with its position as measured by scan and index coordinates. Upon completion, the voltage and position matrix is displayed by assigning either a false color range or a gray scale range to the voltages.

4.3 The image of the microwave scan is interpreted by a qualified user per 6.2 and compared to scans generated from the reference components with the intent to non-destructively assess the overall joint quality.

4.4 This practice provides a method for routine inspection of HDPE electrofused joints prior to placing them in service as well as for continuing in-service inspections of the joints.

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

5. Significance and Use

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

5.2 MW examination is useful for detecting various flaws that are known to occur in polyethylene electrofused joints.

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 Qualifications:*

6.2.1 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, MIL-STD-410, NAS 410, or a similar document. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6.2.2 Personnel shall be certified by the employer or certifying agency, as applicable.

NOTE 3—MIL-STD-410 is canceled and has been replaced with NAS 410; however, it may be used with agreement between contracting parties.

6.3 *Qualification of Nondestructive Agencies:*

6.3.1 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:*

6.4.1 The procedures and techniques to be used shall be as specified in the contractual agreement. The contractual agreement shall include at least the following information:

6.4.1.1 Type, dimensions, location, method of manufacture, and number of artificial flaws to be placed in the reference samples.

6.4.1.2 Method(s) for measuring dimensions of artificial flaws in the reference samples and tolerance limits if different than specified in Section 10.

6.5 *Scope of Examination:*

6.5.1 The scope of the intended examination shall be included in the contractual documents and shall include these defined items.

6.5.1.1 Size and type of pipe to be examined.

6.5.1.2 Size and type of electrofusion joint or coupling to be examined.

6.5.1.3 Number or percentage of joints to be examined.

6.5.1.4 The stage(s) in the manufacturing process at which the joints will be examined.

6.5.1.5 The surface condition requirement of the inspected area.

6.6 *Reporting Criteria:*

6.6.1 Reporting criteria for the examination results shall be in accordance with Section 15 unless otherwise specified. The report shall include at least the following information:

6.6.1.1 Requirements for permanent records of the response from each joint, if applicable.

6.6.1.2 Contents of examination report.

6.7 *Repaired/Reworked Items:*

6.7.1 Re-examination of repaired/reworked items is not addressed in this standard and if required or permitted, shall be specified in the contractual agreement.

7. Surface Preparation

7.1 All inspection surfaces shall be clean and free of scale, dirt, grease, paint, or other foreign material that could interfere with interpretation of examination results. The methods used for cleaning and preparing the surfaces for microwave examination shall not be detrimental to the base material or the surface finish. Excessive surface roughness or scratches can produce signals that interfere with the examination.

7.2 **Warning—**Do not use mechanical devices (such as flapper wheels, grinders, sanders, etc.) to clean PE joints or any part to be inspected. This action renders the part unacceptable for inspection.

7.3 Surfaces should be smooth and free of any deep grooves, gouges, dents, or other surface geometry that may adversely impact the inspection. Surface flaws or markings of sufficient size and/or depth to be seen in the scan image shall be noted in the inspection report as "surface flaw." The parties using or referencing this standard shall determine if the flaws are of sufficient depth to render the part unacceptable.

7.4 In order to aid microwave examination, the electrode connections can be removed from the OD side of the joint (that is, the side of the joint to be examined) after the joint has been fused. Do not remove any electrodes of couplings that have not been fused.

8. Apparatus

8.1 A MW transducer with a single frequency, or a frequency range if a swept frequency device is used, shall be used for this examination. The frequency or frequency range selected shall be shown to be capable of detecting the reference flaws of the types described in Section 10 to the extent required in the standardization and procedure qualification described in Sections 11 and 12.

8.2 The transducer shall be mounted in a probe assembly and shall be capable of detecting the reference flaws of the types described in Section 10 to the extent required in the standardization and procedure qualification described in Sections 11 and 12.

8.3 The stand-off and orientation (that is, E or H Field) of the probe shall be capable of being adjusted to produce a satisfactory signal-to-noise (S/N) ratio for the detection of the required flaws as compared to background "noise" response from irregularities such as surface roughness, labels, and wire signal return.

8.4 The final configuration of the probe and equipment shall be selected to produce a desirable S/N for the inspection. For example, the minimum value for the S/N for the smallest flaw in the reference pipe described in 10.3 should be at least 1.5. A higher minimum value is desirable and may be specified by the contracting agency.

8.5 The equipment is set up such that the scan direction is axial to the pipe and the index is in the circumferential direction. Select a scan speed and index that provides a reasonable total scan time without sacrificing S/N quality. Typically, a 0.1 in. (2.5 mm) index is chosen and a maximum index is considered to be 0.24 in. (6.4 mm).

8.6 Encoder positional information is calibrated and verified in both the circumferential and axial directions from a reference start position and shall be accurate to within 1 % of the total scan length or 0.4 in. (10 mm), whichever is less. Calibration should be performed on a regular basis (for example, daily) with verification occurring prior to the start of any inspection.

8.7 The position of the scanner shall be set such that as much of the electrofusion joint (includes the fused area of the pipe) is inspected as possible. Total scan length is dependent on the type and size of the electrofusion coupling. The scan direction is displayed as the "Y" axis (axial direction) and the index direction is the "X" axis (circumferential directions).