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.

Designation: E1736 − 15 (Reapproved 2022)

Standard Practice for Acousto-Ultrasonic Assessment of Filament-Wound Pressure Vessels[1]

This standard is issued under the fixed designation E1736; 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 a procedure for acousto-ultrasonic (AU) assessment of filament-wound pressure vessels. Guidelines are given for the detection of defect states and flaw populations that arise during materials processing or manufacturing or upon exposure to aggressive service environments. Although this practice describes an automated scanning mode, similar results can be obtained with a manual scanning mode.

1.2 This procedure recommends technical details and rules for the reliable and reproducible AU detection of defect states and flaw populations. The AU procedure described herein can be a basis for assessing the serviceability of filament-wound pressure vessels.

1.3 The objective of the AU method is primarily the assessment of defect states and diffuse flaw populations that influence the mechanical strength and ultimate reliability of filament-wound pressure vessels. The AU approach and probe configuration are designed specifically to determine composite properties in lateral rather than through-the-thickness directions.[2]

1.4 The AU method is not for flaw detection in the conventional sense. The AU method is most useful for materials characterization, as explained in Guide E1495, which gives the rationale and basic technology for the AU method. Flaws and discontinuities such as large voids, disbonds, or extended lack of contact of interfaces can be found by other nondestructive examination (NDE) methods such as immersion pulse-echo ultrasonics.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this practice.

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 *ASTM Standards:*[3]

E543 Specification for Agencies Performing Nondestructive Testing

E1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves

E1067 Practice for Acoustic Emission Examination of Fiberglass Reinforced Plastic Resin (FRP) Tanks/Vessels

E1316 Terminology for Nondestructive Examinations

E1495 Guide for Acousto-Ultrasonic Assessment of Composites, Laminates, and Bonded Joints

2.2 *ASNT Standards:*[4]

ANSI/ASNT CP-189 Personnel Qualification and Certification in Nondestructive Testing

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

2.3 *AIA Standard:*[5]

NAS-410 Certification and Qualification of Nondestructive Test Personnel

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

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[2] Vary, A., "Acousto-Ultrasonics," *Nondestructive Testing of Fibre-Reinforced Plastics Composites*, Vol 2, J. Summerscales, ed., Elsevier Science Publishers Ltd., Barking, Essex, England, 1990, Chapter 1, pp. 1-54.

[3] 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.

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

[5] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

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2.4 *ISO Standard:*[6]

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

3. Terminology

3.1 *Definitions*—Relevant terminology and nomenclature are defined in Terminology E1316 and Guide E1495.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *composite shell*—a multilayer filament-winding that comprises a second shell that reinforces the inner shell. The composite shell consists of continuous fibers, impregnated with a matrix material, wound around the inner shell, and cured in place. An example is the Kevlar-epoxy filament-wound spherical shell shown in Fig. 1. The number of layers, fiber orientation, and composite shell thickness may vary from point to point (Fig. 2). The examination and assessment of the composite shell are the objectives of this practice.

3.2.2 *filament-wound pressure vessel*—an inner shell overwrapped with composite layers that form a *composite shell*. The inner shell or liner may consist of an impervious metallic or nonmetallic material. The vessel may be cylindrical or spheroidal and will have at least one penetration with valve attachments for introducing and holding pressurized liquids or gases.

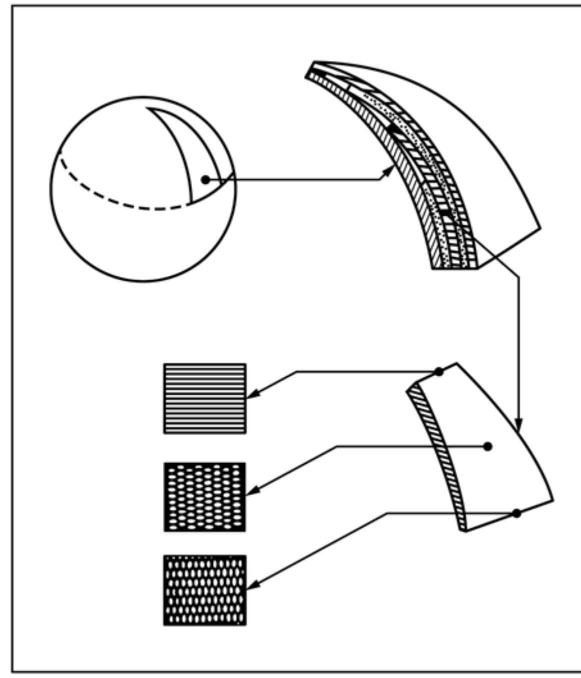

FIG. 2 Representation of Filament-Wound Composite Shell Layers Showing Typical Thicknesses and Layering Variations

4. Significance and Use

4.1 The AU method should be considered for vessels that are proven to be free of major flaws or discontinuities as determined by conventional techniques. The AU method may be used for detecting major flaws if other methods are deemed impractical. It is important to use methods such as immersion pulse-echo ultrasonics (Practice E1001) and acoustic emission (Practice E1067) to ascertain the presence of major flaws before proceeding with AU.

4.2 The AU method is intended almost exclusively for materials characterization by assessing the collective effects of dispersed defects and subcritical flaw populations. These are material aberrations that influence AU measurements and also underlie mechanical property variations, dynamic load response, and impact and fracture resistance.[7]

4.3 The AU method can be used to evaluate laminate quality using access to only one surface, the usual constraint imposed by closed pressure vessels. For best results, the AU probes must be fixtured to maintain the probe orientation at normal incidence to the curved surface of the vessel. Given these constraints, this practice describes a procedure for automated AU scanning using water squirters to assess the serviceability and reliability of filament-wound pressure vessels.[8]

5. Limitations

5.1 The AU method possesses the limitations common to all ultrasonic methods that attempt to measure either absolute or relative attenuation. When instrument settings and probe configurations are optimized for AU, they are unsuitable for conventional ultrasonic flaw detection because the objective of AU is not the detection and imaging of individual micro- or macro-flaws.

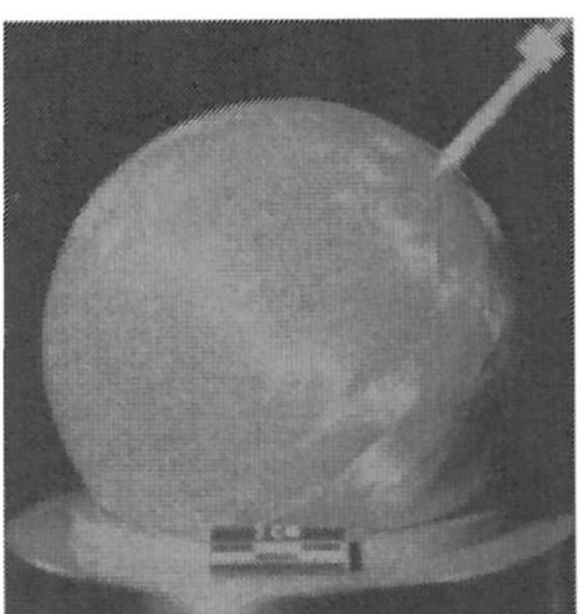

FIG. 1 Kevlar-Epoxy Filament-Wound Shell

[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[7] Vary, A., "Material Property Characterization," *Nondestructive Testing Handbook—Ultrasonic Testing*, Vol 7, A. S. Birks, R. E. Green, Jr., and P. McIntire, eds., American Society for Nondestructive Testing, Columbus, OH, 1991, Section 12, pp. 383–431.

[8] Sundaresan, M. J., Henneke, E. G., and Brosey, W. D., "Acousto-Ultrasonic Investigation of Filament-Wound Spherical Pressure Vessels," *Materials Evaluation*, Vol 49, No. 5, 1991, pp. 601–6012.