Designation: E2581 – 14 (Reapproved 2023)

Standard Practice for Shearography of Polymer Matrix Composites and Sandwich Core Materials in Aerospace Applications[1]

This standard is issued under the fixed designation E2581; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice describes procedures for shearography of polymer matrix composites and sandwich core materials made entirely or in part from fiber-reinforced polymer matrix composites. The composite materials under consideration typically contain continuous high modulus (greater than 20 GPa (3 × 106 psi)) fibers, but may also contain discontinuous fiber, fabric, or particulate reinforcement.

1.2 This practice describes established shearography procedures that are currently used by industry and federal agencies that have demonstrated utility in quality assurance of polymer matrix composites and sandwich core materials during product process design and optimization, manufacturing process control, after manufacture inspection, and in service inspection.

1.3 This practice has utility for testing of polymer matrix composites and sandwich core materials containing but not limited to bismaleimide, epoxy, phenolic, poly(amideimide), polybenzimidazole, polyester (thermosetting and thermoplastic), poly(ether ether ketone), poly(ether imide), polyimide (thermosetting and thermoplastic), poly(phenylene sulfide), or polysulfone matrices; and alumina, aramid, boron, carbon, glass, quartz, or silicon carbide fibers. Typical as-fabricated geometries include uniaxial, cross-ply and angle-ply laminates; as well as honeycomb and foam core sandwich materials and structures.

1.4 This practice does not specify accept-reject criteria and is not intended to be used as a means for approving polymer matrix composites or sandwich core materials for service.

1.5 To ensure proper use of the referenced standards, there are recognized nondestructive testing (NDT) specialists that are certified according to industry and company NDT specifications. It is recommended that an NDT specialist be a part of any composite component design, quality assurance, in-service maintenance, or damage examination activity.

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:*[2]

C274 Terminology of Structural Sandwich Constructions (Withdrawn 2016)[3]

D3878 Terminology for Composite Materials

D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation

E543 Specification for Agencies Performing Nondestructive Testing

E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases (Withdrawn 2015)[3]

E1316 Terminology for Nondestructive Examinations

E1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases (Withdrawn 2015)[3]

E1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases (Withdrawn 2015)[3]

[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] The last approved version of this historical standard is referenced on www.astm.org.

E2533 Guide for Nondestructive Examination of Polymer Matrix Composites Used in Aerospace Applications
E2982 Guide for Nondestructive Examination of Thin-Walled Metallic Liners in Filament-Wound Pressure Vessels Used in Aerospace Applications
F1364 Practice for Use of a Calibration Device to Demonstrate the Inspection Capability of an Interferometric Laser Imaging Nondestructive Tire Inspection System

2.2 *ASNT Standards:*[4]
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel

2.3 *AIA Document:*[5]
NAS-410 Certification and Qualification of Nondestructive Test Personnel

2.4 *BSI Document:*[6]
EN 60825-1 Safety of Laser Products - Part 1: Equipment Classification, Requirements, and User's Guide

2.5 *LIA Document:*[7]
ANSI Z136.1-2000 Safe Use of Lasers

2.6 *Federal Standards:*[8]
21 CFR 1040.10 Laser products
21 CFR 1040.11 Specific purpose laser products
29 CFR 1910.95 Occupational Noise Exposure

3. Terminology

3.1 *Definitions*—Definition of terms related to structural sandwich constructions, NDT, and composites appearing in Terminologies C274, E1316, and D3878, respectively, shall apply to the terms used in this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aerospace*—any component that will be installed on a system that flies.

3.2.2 *beam splitter*—an optical element capable of splitting a single beam of coherent laser light into two beams. Beam splitters are key elements of Michelson Type Image Shearing Interferometers.

3.2.3 *cognizant engineering organization*—the company, agency, or other authority responsible for the design or after delivery, end use of the system or component for which laser holographic or laser shearographic examination is required; in addition to design personnel, this may include personnel from material and process engineering, stress anaylsis, NDT, or quality groups and others as appropriate.

3.2.4 *coherent light source*—a light source that converts electrical energy to a monochromatic beam of light having uniform phase over a minimum specified length known as the coherent length.

3.2.5 *component*—the part(s) or element(s) of a system described, assembled, or processed to the extent specified by the drawing.

3.2.6 *composite material*—see Terminology D3878.

3.2.7 *composite component*—a finished part containing composite material(s) that is in its end use application configuration and which has undergone processing, fabrication, and assembly to the extent specified by the drawing, purchase order, or contract.

3.2.8 *core crush*—a collapse, distortion, or compression of core material in a sandwich structure.

3.2.9 *core separation*—a partial or complete breaking of honeycomb core node bonds.

3.2.10 *disbond, unbond*—see Terminology D3878.

3.2.11 *de-correlation*—loss of shearography phase data caused by test part deformation exceeding the resolution of the shearing interferometer or motion occurs between the test object and shearing interferometer during data acquisition.

3.2.12 *delamination*—see Terminology D3878.

3.2.13 *displacement derivatives ($\partial w/\partial x$)*—rate of spatial displacement change, where w is the surface displacement and x is the surface coordinates.

3.2.14 *fringe pattern*—a set of lines in a subtraction or wrapped phase shearogram that represents the locus of equal out-of-plane deformation derivative.

3.2.15 *impact damage*—fracturing of epoxy matrix, fiber breakage, inter-laminar delamination of monolithic composites, composite sandwich structure face sheets due to impact, characterized by visible dimple surface compression, or fiber breakage caused by impact strike and non-visible subsurface matrix cracking and delamination.

3.2.16 *inclusion*—foreign objects or material including but not limited to particles, chips, backing films, razor blades, or tools of varying sizes which are inadvertently left in a composite lay-up.

3.2.17 *indication*—the observation or evidence of a condition resulting from the shearographic examination that requires interpretation to determine its significance, characterized by dimensions, area, s/n ratio, or other quantitative measurement.

3.2.18 *laser shearography inspection, shearography inspection, shearography*—inspection method utilizing interferometric imaging of deformation derivatives compared between different strain states and designed to reveal non-homogeneities, material changes and structural defects throughout the volume of the material.

3.2.19 *out-of-plane displacement*—the local deformation of a test part, normal to the surface, caused by the application of an engineered force acting on a non-homogeneity or defect in a composite material.

[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.
[6] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.
[7] Available from the Laser Institute of America, 13501 Integrity Drive, Suite 128, Orlando FL 32826.
[8] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.