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Designation: ~~E2580 – 17~~ E2580 – 24

Standard Practice for Ultrasonic Testing of Flat Panel Composites and Sandwich Core Materials Used in Aerospace Applications[1]

This standard is issued under the fixed designation E2580; 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 ~~establishes~~covers two procedures for ultrasonic testing (UT) of flat panel (parallel surfaces) composites and flat sandwich core ~~panels (parallel surfaces).~~ panels. Typical as-fabricated lay-ups include uniaxial, cross ply, and angle ply ~~laminates;~~laminates, as well as honeycomb sandwich core materials. These procedures can be used throughout the life cycle of the ~~materials;~~materials: product and process design optimization, on line process control, after manufacture inspection, and ~~in service~~ in-service inspection. Contact methods, such as angle-beam techniques using shear waves, ~~or surface-beam techniques using Lamb waves,~~ are not discussed.

1.2 Ultrasonic testing is a common subsurface method for detection of laminar ~~oriented~~ discontinuities. Two techniques can be considered based on panel surface accessibility; pulse echo for one sided and through transmission (bubblers/squirters) for two sided. As used in this practice, both require the use of a pulsed straight-beam ultrasonic longitudinal wave followed by observing indications of either the reflected (pulse-echo) or received (through transmission) wave. The general types of anomalies detected by both techniques include foreign materials, delamination, disbond/un-bond, fiber de-bonding, inclusions, porosity, and voids.

1.3 This practice provides two ultrasonic test procedures. These test procedures can be applied to small area manual scanning and large area automated scanning. Each has its own merits and requirements for inspection and shall be selected as agreed upon in a contractual document.

1.3.1 *Test Procedure A, Pulse Echo ~~(non-contacting and contacting),~~(Non-contacting and Contacting),* is at a minimum a single transducer transmitting and receiving a longitudinal wave in the range of ~~0.5 to 20 MHz~~ 0.5 MHz to 20 MHz (see Fig. 1). This procedure requires access to only one side of the specimen. This procedure can be conducted by automated or manual means. Automated and manual test results may be imaged or recorded.

1.3.2 *Test Procedure B, Through Transmission,* is a combination of two transducers. One transmits a longitudinal wave and the other receives the longitudinal wave in the range of ~~0.5 MHz~~ 0.5 MHz to 20 MHz (see Fig. 2~~).~~ for an example set-up using squirters). This procedure requires access to both sides of the specimen. This procedure is automated and the examination results are recorded.

1.4 This practice does not specify accept-reject criteria.

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

[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.
Current edition approved ~~Nov. 1, 2017~~Feb. 1, 2024. Published ~~December 2017~~March 2024. Originally approved in 2007. Last previous edition approved in ~~2012~~2017 as ~~E2580 - 12.~~E2580 – 17. DOI: ~~10.1520/E2580-17.~~10.1520/E2580-24.

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

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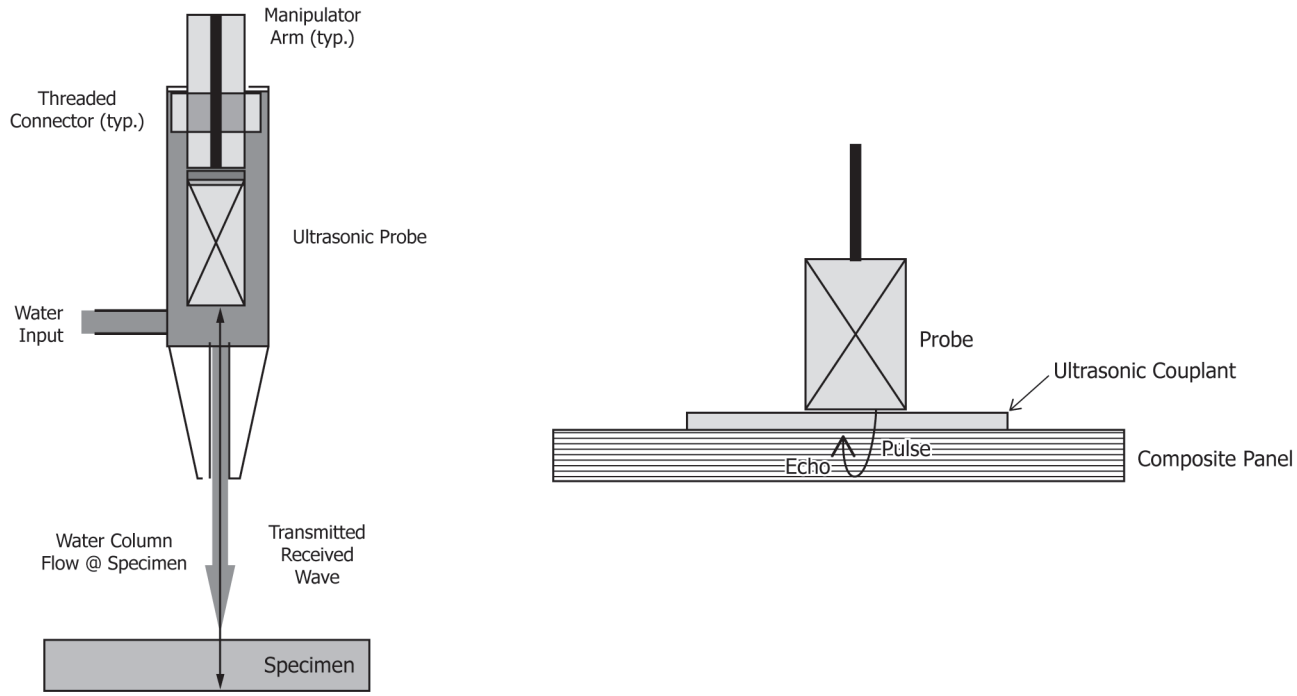

FIG. 1 Test Procedure A, Example Pulse Echo Apparatus ~~Set-up~~Set-ups

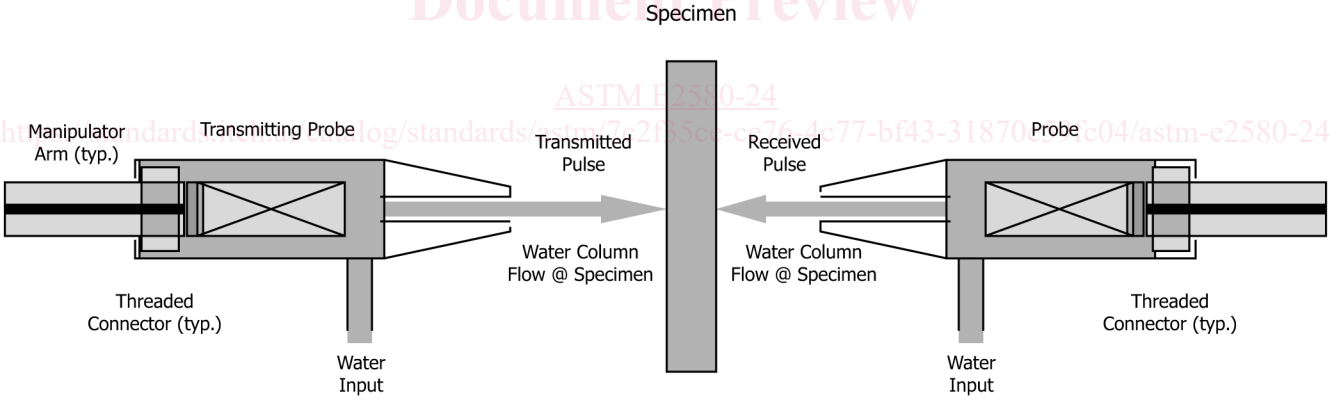

FIG. 2 Test Procedure B, Through Transmission Apparatus Set-up Using Squirters

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]

[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.

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
E317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments
E543 Specification for Agencies Performing Nondestructive Testing
E1065/E1065M Practice for Evaluating Characteristics of Ultrasonic Search Units
E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases (Withdrawn 2015)[3]
E1316 Terminology for Nondestructive Examinations
E1324 Guide for Measuring Some Electronic Characteristics of Ultrasonic Testing Instruments
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]

2.2 *SAE Standards:*[4]
ARP 5605 Solid Composite Laminate NDI Reference Standards, Issued 2001-09Standards
ARP 5606 Composite Honeycomb NDI Reference Standards, Issued 2001-09Standards

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

2.4 *ASNT Standards:*[6]
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
ANSI/ASNT CP-189 Standard for Qualification and Certification or Nondestructive Testing Personnel

2.5 *ISO Standard:*[7]
ISO 9712 NDT–Qualification and Certification of NDT Personnel in the Applicable Product Sector "Aerospace"

3. Terminology

3.1 *Definitions*—Terminology in accordance with Terminologies C274, E1316, and D3878 shall be used where applicable.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flat panel composite, n*—any fiber reinforced composite lay-up consisting of laminate (plies) with one or more orientations with respect to some reference direction that are consolidated by press or autoclave to yield a two-dimensionally flat article of finite thickness.

3.2.2 *sandwich core material, n*—a structural panel made up of two relatively thin outer skins of composite laminate or other material, such as metal or wood, separated by and bonded to a relatively thick lightweight inner core such as honeycomb, open and close cell foam, wave formed material, bonded composite tubes, or naturally occurring material such as balsa wood.

4. Summary of Practice

4.1 This practice describes two procedures for detecting anomalies in flat panel composite and flat sandwich core panels using ultrasonic longitudinal waves coupled by either contact (Procedure A) or bubbler/squirter (Procedure B). Equipment, reference blocks, examination and evaluation procedures, and documentation are described in detail.

5. Significance and Use

5.1 This practice is intended primarily for the testing of flat panel composites and sandwich core panels to an acceptance criteria most typically specified in a purchase order or other contractual document.

5.2 *Basis of Application*—There are areas in this practice that require agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization.

6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this standard.

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

6.2 *Personnel Qualification*—If specified in the ~~Contractual~~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, NAS-410, or 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 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with 8.4~~8.4.~~, unless otherwise specified.

6.5 *Timing of Examination*—The timing of examination shall be in accordance with ~~8.2~~8.2 and 8.3~~8.3.~~, unless otherwise specified.

6.6 *Extent of Examination*—The extent of examination shall be in accordance with ~~8.5~~8.5 unless otherwise specified.

6.7 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with ~~14.1~~14.1 unless otherwise specified. Since acceptance criteria (for example, for reference radiographs) are not specified in this standard, they shall be specified in the contractual agreement.

6.8 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this standard and if required shall be specified in the contractual agreement.

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7. Equipment and Materials

7.1 *Equipment*

7.1.1 *Operation*—Test equipment shall be capable of providing uniform, repeatable, and controlled operation.

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7.1.2 *Electronic Equipment*—The electronic equipment should be capable of producing and processing electronic signals at frequencies in the range of search unit frequencies being used.

7.1.3 *Search Unit(s)*—The search unit(s) selected should be compatible with the electronic equipment being used and with the material to be inspected. The search unit should match the intended squirter(s) or contact. Only longitudinal, straight-beam ~~(longitudinal)~~ search units, with flat or focused acoustic lenses, should be used.

7.1.4 *Alarm*—The alarm or threshold level should be adjustable to allow triggering at any commonly required level of indication amplitude. Alarms are not required on systems that record amplitude recordings.

7.1.5 *Alarm Gate Synchronization*—In the pulse echo mode, ensure that the alarm gate tracks the inspection area. The gate should lock on the first interface pulse from the test piece rather than on the initial pulse from the system. In the through transmission mode, the alarm gate should be wide enough to cover any negative or positive movement (left to right) in the horizontal plane.

7.1.6 *Manipulating Equipment* should be provided to adequately support the search tube(s) and allow angular adjustment in two mutually perpendicular planes. The search unit manipulator shall be capable of providing the adjustments necessary to properly position the search unit during testing. The scanning and indexing apparatus should have sufficient structural rigidity to provide support for the manipulator and should allow smooth, accurate positioning of the search unit. The scanning apparatus should be sufficiently rigid to keep search unit backlash to within tolerances as specified in the contractual agreement.

7.1.7 *Tank or Gantry System*—The tank or gantry system should permit accurate positioning of the search unit, reference standards, and part or material to be examined.

7.1.8 *Squirter*—The squirter equipment shall be capable of supplying a laminar flow of coupling fluid from the transducer to the part being tested at all angles used.

7.1.9 *Scan-Record*—The recording shall not exhibit backlash or hysteresis that would hinder detection or evaluation of discontinuities.

7.1.10 *Composite Reference Blocks*—For the applicable testing system, the responses from reference ~~block~~block(s) and part shall be similar to the extent that standardization of the testing system can be accomplished and demonstrated to provide a known and acceptable detection level in the part. Reference blocks contain either structural anomalies or foreign inclusions. Structural anomalies are those that are known to be possible during the life cycle of the material. Debonding during manufacturing or delamination during in-service may be represented by the block. Foreign inclusions most commonly encountered during manufacturing are used in the reference blocks.

7.1.11 *Transfer Cutouts*—When non-contact through-transmission is used transfer cutouts may be used in lieu of reference blocks when agreed upon contractually. The size of the transfer cutouts shall be agreed contractually. The transfer cutouts must provide sufficient attenuation to simulate voids or unbonds in the part. Transfer cutouts shall be attached to the part and be placed to cover changes in part configuration and alignment.

7.2 *Materials:*

7.2.1 *Flat Panel Specimens*—Processing guidelines that facilitate fabrication of flat panel composite specimens made from unidirectional tape or using orthogonal weave patterns are found in Guide D5687/D5687M. For specimen preparation using other processing techniques, for example, pultrusion, filament winding, and resin transfer molding, processing guidelines are not available and shall be agreed upon by the using parties.

7.2.2 *Sandwich Core Specimens*—Processing guidelines for fabrication of sandwich construction specimens are diverse and shall be agreed upon by the using parties.

7.2.3 *Transfer Cutouts*—Transfer cutouts shall be made of two layers of lead foil tape cut to size.

7.2.4 *Couplants*—~~Immersion and~~ Air, immersion, or contact couplants shall provide intimate coupling between search unit and ~~part; shall~~ part, be compatible with the ~~part;~~part, and ~~shall~~ be easily removed from the part using an applicable cleaning process.

8. General Requirements

8.1 In-process testing of flat panel composite or honeycomb structure shall be conducted using automated equipment capable of electronically recording the test ~~output or manual contact during indication evaluation.~~ output. Evaluation of indications may be conducted using manual contact. There shall be a direct correlation of the electronic recording and the tested specimen. Transducer frequency shall be determined by the material's apparent attenuation and the required acceptance criteria. ~~Scan increment shall be set to provide three ultrasonic signal violations from the standard at the specified threshold level.~~The diameter of the search unit shall be appropriate to the detection requirements of the inspection.

8.2 In-service testing ~~shall~~may be conducted using manual contact techniques, these tests are for the determination of suspected areas of damage. Testing shall be conducted using a reference standard. This reference standard shall be of the same configuration as the test ~~specimen or as agreed upon contractually. This reference standard shall be acoustically similar~~specimen, acoustically similar, and contain simulated or actual ~~discontinuities.~~discontinuities or as agreed upon contractually.

8.3 In-process testing of flat panel composites shall be for the detection of foreign materials, delaminations, voids, and porosity. In-process testing of honeycomb structures shall be for the detection of non-bonds between the face sheets and core. In-service testing of flat panel composites shall be for the detection of damage such as delaminations. In-service testing of honeycomb structure shall be for unbond between the face sheet and core.

8.4 *Material Condition*—Perform ultrasonic testing of parts or materials that possess a clean and smooth surface.

8.5 *Coverage*—In all examinations, perform scanning to locate discontinuities that are oriented parallel with the entry surface. The scanning speed and index increment and step size shall be such that the target simulated anomaly registers three times at a contractually agreed upon threshold.

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8.6 *Ultrasonic Frequency*—For a particular test select the frequency based on the material being inspected and of the anticipated type of discontinuities.

8.7 *Evaluation*—Evaluate each discontinuity to determine its type, size, location, and conformance to the applicable accept/reject criteria. Specific discontinuity evaluation procedures shall be agreed upon contractually.

8.8 *Technique Record*—For each part inspected, a technique record shall be completed for each discontinuity detection scan and indication evaluation set-up ~~used.~~ used and approved by the Level III. The technique record shall identify the part, the ~~area or zone, or bond-line~~ area/zone/bond-line of the part being inspected, the inspector, the inspection procedure, and the equipment used. The record shall include cross-sectional sketches as necessary to show part coverage. The technique record shall note instrument control settings such that the test can be repeated.

TEST PROCEDURES

9. Procedure A

9.1 ~~Test procedure A (Pulse-Echo) is a single transducer transmitting and receiving a longitudinal wave in the range of 0.5 MHz to 20 MHz (see Fig. 1). This procedure can be automated or manual. The test results may be recorded. This procedure requires access to one side of the specimen.~~*Test Procedure A (Pulse-Echo):*

9.1.1 Select the ultrasonic transducer based on the specific requirements of the material, discontinuity size, resolution, and life cycle requirements. Ensure a signal-to-noise ratio of at least 3 to 1.

9.1.2 Select the reference block based on the objective of the test. Step wedge blocks may be useful for ply count and de-bond or delamination. Flat bottom holes may be useful to determine the size of a given discontinuity at a known ply or material thickness.

9.1.3 Select the frequency based on the acoustic properties of the material and the testing sensitivity required. The frequency should provide a discontinuity to parent material signal ratio of 3 to 1.

9.1.4 Set the pulse repetition rate to prevent aliasing.

9.2 ~~*Pulse-Echo Testing Application*~~*Pulse-Echo Testing Application:*

9.2.1 ~~*Non-Contact Testing*~~*Non-Contact Testing:*

9.2.1.1 Set up part and reference so the entry surface is level with the scanning bridge.

9.2.1.2 ~~Use~~ If using squirters, then use the largest diameter nozzle and shortest free water column possible. For inspection adjust the water flow to eliminate bubbles and entrapped air while providing a sufficiently smooth laminar flow.

9.2.1.3 ~~Normalize beam-to-surface of part.~~Ensure the normality of the beam to the part surface.

9.2.1.4 Check for an adequate and consistent signal by taking cursory scans of the part.

9.2.2 ~~*Contact Testing*~~*Contact Testing:*

9.2.2.1 Clean surface of part and apply the contact couplant that provides the most consistent signal. ~~Select a probe that provides at least a 3:1 signal to noise response from reference standard and provides proper indication sizing capabilities.~~

9.3 ~~*Standardize the System*~~*Standardize the System:*

9.3.1 Standardize the system using the contractually agreed upon reference blocks.

9.3.2 Establish the front and back surface signal positions on the base line of the ultrasonic display.

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