Designation: E1307 – 10

Standard Practice for Surface Preparation and Structural Adhesive Bonding of Precured, Nonmetallic Composite Facings to Structural Core for Flat Shelter Panels[1]

This standard is issued under the fixed designation E1307; 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 Department of Defense.

1. Scope

1.1 This practice covers the materials, processes, and quality controls to be used in the manufacture of durable adhesive bonded, nonmetallic faced, flat sandwich panels for rigid wall relocatable shelters.

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

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C297/C297M Test Method for Flatwise Tensile Strength of Sandwich Constructions

E865 Specification for Structural Film Adhesives for Honeycomb Sandwich Panels

E990 Specification for Core-Splice Adhesive for Honeycomb Sandwich Structural Panels

E1091 Specification for Nonmetallic Honeycomb Core for Use in Shelter Panels

2.2 *Federal Standard:*[3]

FED STD 209 Clean Room and Work Station Requirements

2.3 *Society of Automotive Engineers (SAE) Standard:*[4]

SAE-AMS-S-8802 Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-Adhesion

2.4 *Military Handbook:*[3]

MIL-Handbook 337 Adhesive Bonded Aerospace Structures

3. Significance and Use

3.1 Durable adhesive bonds of composite laminates can be obtained reliably only through proper selection and careful control of the materials used and the steps in the bonding process. The preparation of the composite laminates to obtain surfaces with appropriate characteristics is a critical step. Improper surface preparation can produce seemingly acceptable bonds that can degrade rapidly with time. This practice describes how properly prepared surfaces can be obtained.

3.2 The formation of reproducible, durable, adhesive bonds in structural units requires great care in the selection of materials, the preparation of the surfaces of the parts to be bonded, the fit of parts, and the performance of the steps in the bonding process. Experience has shown that adhesive bonding carried out in accordance with this practice produces reproducible bonds.

4. Materials

4.1 *Materials*—Materials shall be as specified herein or as specified in the contract. All materials shall be stored and handled in such a manner as to provide protection against degrading environments and mechanical damage.

4.2 *Composite Reinforcement and Resin*—The composite reinforcement and resin shall meet the requirements specified in the procurement document.

4.3 *Peel Ply Fabric*—A nonreuseable peel ply shall be used. Closely woven fabric of nylon, polyester, or glass has been

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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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

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found suitable. The peel ply fabric must be compatible with the manufacturing process.

4.4 *Precured Facings*—The facings shall be certified as complying with the reinforcement, resin binder, resin content, and thickness requirements of the procurement document. Facings shall be free of defects that may adversely affect the structural integrity of the bonded panel.

4.5 *Core*—The core material shall be as specified in Specification E1091 or the procurement document and shall meet the requirements of the applicable document.

4.6 *Structural Film Adhesive*—The adhesive shall conform to the requirements of Specification E865. It shall be stored in accordance with the manufacturer's recommendations.

4.7 *Core Splice Adhesive*—The core splice adhesive shall conform to the requirements of Specification E990. It shall be stored in accordance with the manufacturer's recommendations.

5. Facilities

5.1 *Panel Assembly Layup Area*—The panel assembly layup area is an enclosed, environmentally controlled area (ECA) that is continuously controlled for temperature, relative humidity, and concentration of airborne particles. The ECA shall be maintained at a temperature of 24 ± 6°C (75 ± 10°F) and not more than 50 % relative humidity. The temperature and relative humidity shall be recorded continuously. All incoming and recirculated air shall be filtered to control airborne particles. The air handling equipment shall provide at least five air changes per hour in the ECA. The filters shall ensure that the particle count within the ECA will not exceed 7×10^6 particles per cubic metre (200 000 particles per cubic foot) of size 1 μm and larger. The air pressure differential between the ECA and adjacent areas shall be monitored continuously and recorded at least twice weekly. The air pressure in the ECA shall be maintained above that of adjacent areas by a minimum of 50 Pa (0.015 in. Hg). The particle count shall be monitored in accordance with FED STD 209. The recorders shall be calibrated every six months. The ECA shall be conspicuously identified at all entrances as "limited access." Unnecessary traffic within the ECA shall not be permitted. Eating and smoking within the ECA shall not be permitted and the ECA shall be so posted. All material, tools, and equipment used in the ECA shall be clean, low shed, and free from lint, oil, and grease. The use and application of oil, grease, mold release agents, or other possible contaminants within the ECA shall be prohibited. The interior, exposed surfaces of the ECA shall be nonshedding and easily cleaned to minimize dust generation. Any particle-generating preparations such as removal of peel ply, insertion of foam into honeycomb core, or cleaning must be accompanied by filtered vacuum when performed in the ECA.

6. Equipment

6.1 *Platen Press*—Pressure equipment for bonding of shelter panels shall be large enough to permit the bonding of the total panel in one step. The manufacturer shall provide calibration and test data demonstrating that the temperature on the two facings of press platens during lamination will be equal and uniform within 4 % of their nominal temperature. The pressure equipment used for curing the panels shall be capable of applying greater than 140 kPa (20 psi) and 150°C (300°F) over the entire panel surface. Platens shall be flat to within 0.17 mm/m (0.002 in./ft). The pressure equipment shall be equipped with temperature and pressure recorders and controls that accurately control heat-up rate, pressure application, dwell time, cool down (when required), and pressure removal. The pressure equipment shall also be equipped with suitable devices (for example, caul sheets) that facilitate moving the panel layup into the press without misaligning the layup.

6.1.1 *Calibrations, Temperature, and Pressure Requirements and Controls*—Gages shall be calibrated at least every six months by an accredited independent laboratory or by the manufacturer if approved by the purchaser. The latest calibration certificate shall be attached to the equipment near each gage. It shall be demonstrated that the actual bonding pressure is within 10 % of the nominal pressure. It shall also be demonstrated that the average temperatures of the top and bottom panel facings during the bonding process are equal and uniform to within 4 % of the nominal temperature. Thermocouples placed within 150 mm (6 in.) of each corner and at the center of each facing shall be used to demonstrate the uniformity of the temperature. Compliance of the equipment with these requirements shall be verified at intervals not exceeding six months. A permanent record of the pressure, time, and temperature measurements during bonding compliance checks shall be maintained. All calibrations must be traceable to the National Institute of Standards and Technology (NIST).

6.2 *Autoclave*—The autoclave equipment for bonding shelter panels shall be large enough to permit the bonding of entire shelter panel assemblies in one step. The autoclave shall be equipped with vacuum gages and temperature and pressure recorders that accurately control heat-up rate, pressure application, dwell time, cool down, and pressure removal. Vacuum venting facilities shall be provided. The autoclave equipment used for curing the panels shall be capable of applying greater than 140 kPa (20 psi) and 150°C (300°F). The manufacturer shall provide calibration and test data demonstrating that the temperature was maintained within 4 % of the nominal temperature and the pressure was maintained within 10 % of the operating pressure.

6.3 *Testing Equipment*—The supplier shall have available sufficient testing equipment to ensure that all process control specimen preparation and testing required by this practice can be accomplished. All calibrations of test equipment required by this practice shall be traceable to the NIST.

7. Preparation of Composite Facings

7.1 The composite reinforcement, number of plies, resin, and cure cycle shall meet the requirements as specified in the shelter specification.

7.2 *Peel Ply*—A peel ply shall be included as the surface layer for the side of the precured skin that will be later bonded. The peel ply shall extend past all edges.

7.3 *Peel Ply Removal*—Prior to bonding, remove the peel ply from the faying surface to provide a clean, high-area surface ideal for bonding. Removal shall be accomplished in the ECA.

8. Quality Assurance of Composite Facings

8.1 *Handling*—Parts with the peel ply removed or being removed shall be handled using clean gloves or other methods to prevent surface contamination.

8.2 *Marking*—All processed parts shall be marked with the date and time of manufacture. If the surface with the peel ply removed must be marked, marking shall be lightly scribed.

8.3 *Written Process Procedure*—Each processor shall keep a written record of the date and time the peel ply was removed, the time placed into the ECA, and the time the facing was bonded.

8.4 *Visual Inspection*—After removal of the peel ply, the faying surface shall be inspected for defects as defined by the procurement document. Any defects shall be recorded.

9. Shelter Panel Construction

9.1 The matrix resin, fiber reinforcement, thickness of the facings, edge closure details, core type, and the weights and sizes of the panels shall be as specified in the procurement document. Unless otherwise specified, the allowable deviation from flatness of the bonded panel shall be within 1.5 mm (1⁄16 in.) when measured as specified in 14.3.1 against the concave side of the panel. With the panel in a horizontal position, lay the straight edge on the panel surface and measure the maximum gap between the straightedge and the panel. The facing surfaces may contain local bulges or depression within the allowable flatness tolerance specified above.

9.2 *Edge Closures and Framing Members*—The edge closures and framing members shall be as specified in the shelter design specification. When the shelter design requires the edge closures and framing members to be bonded simultaneously with panel bonding, the edge closures and framing members shall be bonded to the facings with the adhesive specified in 4.6 and to the core with adhesive specified in 4.7.

9.3 *Preparation of Composite Facing and Edge Closures*—Cutting, trimming, and sizing shall be made prior to surface preparation. Silicone based cutting fluids shall not be used in processing of detailed parts. The prepared composite facings and framing members shall be free of contaminants before application of the adhesive. Parts requiring identification shall be marked with inks or methods approved for bonding.

9.4 *Preparation of Core*—The core shall be cleaned of dust with dry, oil-free, filtered compressed air or vacuumed prior to delivery to the panel assembly layup area. When honeycomb core is used and the cells are filled with plastic foam, the surface of the installed foam shall be at least 1.5 mm (1⁄16 in.) below the surface of the honeycomb on both surfaces, and all bonding surfaces shall be free of foam, dust, and contaminants by vacuuming. When a panel requires more than one sheet of core, the seam between pieces shall be spliced so that the uniformity of thickness is maintained across the seam. The core splicing material must be impermeable to water and serve as a barrier to water migration and meet the requirements of Specification E990. The core splicing method and adhesive used shall be such that the shear strength of the splice shall be equal to or greater than the core shear strength. Any crushed corners and edges of the core sheets shall be repaired and the sheet resquared prior to splicing and lamination. Where the shelter design requires that all framing members be bonded simultaneously with panel bonding, the core shall fit into the panel layup such that the gap between the core and the framing members is no more than 1.5 mm (1⁄16 in.). Adhesive meeting the requirements of Specification E990 must fill this gap and provide a good bond to the framing members. The volatile content of the core (including moisture) at the time of panel assembly shall not exceed 2% by mass for honeycomb and balsa wood when tested in accordance with 14.1. Other core materials shall meet the requirements specified in the design specification.

9.5 *Application of Adhesive*—The procedures for application of adhesive shall be in conformance with the manufacturer's instructions in the process specification approved by the purchaser of the adhesive. Film adhesives shall be brought to the temperature of the panel assembly layup room prior to removal of the protective wrapper.

9.6 *Assembly and Handling of Panel Components*—The method of handling the core with the facings shall ensure that there will be no relative movement between core and facing during and after the bonding of components. Panel components shall not vary in thickness sufficiently to cause unacceptable pressure deviations on the panel from nominal pressure during bonding.

9.7 *Bonding Operation*—The bonding pressure (gage) shall be recorded for each bonding cycle. The pressure shall be maintained within 10 % of the nominal pressure during the bonding cycle. Charts relating equipment gage pressure to panel size for the required bonding pressure shall be attached to each pressure application device. The bonding temperature for each bonding cycle shall be recorded in a permanent record.

9.7.1 *Platen Press Bonding*—Platen press equipment that is used for structural adhesive bonding of precured flat composite facings to core, shall comply with the requirements of 6.1. Temperature and pressure requirements in accordance with the applicable cure cycles shall be specified on the pertinent shop work orders.

9.7.2 *Autoclave Bonding Equipment*—Autoclave bonding equipment shall comply with the requirement of 6.2. Temperature, vacuum, and pressure requirements in accordance with the applicable cure cycles shall be specified on the pertinent shop work orders.

9.8 *Sealed Edges*—All panel edges shall be sealed using procedures detailed on the design drawings. If unspecified, edges shall be sealed using polysulfide sealer in accordance with SAE-AMS-S-8802.

10. Process Control

10.1 *Process Control Specimens:*

10.1.1 A process control panel shall be prepared for each day's production of shelter panels. Each process control panel shall be of sufficient size to yield at least nine flatwise tensile specimens (see 12.1). The facings shall be reinforced composites meeting the requirements of 4.4. The process control panel shall be assigned a lot number traceable to the production lot number.

10.1.2 The process control panel shall be fabricated using the same techniques as the production panels and shall be bonded during one of the panel curing cycles.

10.1.3 Three specimens obtained from these process control panels, when tested in accordance with 12.1, shall have average flatwise tensile strengths of that specified in the procurement document. In the event of failure, the remaining six flatwise tensile specimens shall be tested and their average flatwise tensile strength shall not be less than the minimum flatwise tensile strength of that specified in the procurement document.

10.2 *Fabricated Shelter Panels*—Completely fabricated shelter panels processed in accordance with the requirements of this practice shall be inspected and tested as specified. Each panel shall be examined prior to subsequent processing. The shelter panels shall be inspected and tested in accordance with 14.3.1-14.3.3, in addition to any inspection requirements of the end item specification. There shall be no unbonded areas in the bonded panel.

10.2.1 *Handling*—The laminated panels shall be handled with care to avoid damage that would cause their rejection.

10.2.2 *Identification*—Each shelter panel shall be permanently identified and legibly marked with a part number, a production lot number, and with the date of manufacture. This marking shall be located in an area specified by the purchaser so as to be clearly visible on the assembled shelter.

10.2.3 *Traceability Records*—Records of the lot number, date of manufacture of the adhesive used in each panel, and records of test results, shall be either maintained by the manufacturer for a period of three years after completion of the contract or furnished to the purchaser.

10.3 *Workmanship*—Shelter panels shall conform to the requirements of this practice and the shelter specification. No defect shall exceed the limits stated in this practice and the shelter specification.

10.4 *Storage*—Bonded panels prepared in accordance with this practice shall be stored until required in such a manner as to protect them against damage and deterioration.

11. Quality Assurance Provisions

11.1 *Responsibility for Inspection*—Unless otherwise specified by the purchaser, the manufacturer is responsible for meeting all inspection requirements. The manufacturer may use its own or any other suitable facilities approved by the purchaser. The purchaser has the right to perform any of the tests and inspections set forth in this practice and shall be provided access to every facility for careful inspection and sampling.

11.1.1 *Acceptability Criteria*—The bonding process shall conform to all requirements specified herein, and the test specimens shall pass all applicable examinations and tests of this practice. Failure to meet any test shall be cause for complete review of each process variable in the presence of the purchaser's representative and for requalification of each constituent material to the extent necessary to determine the cause of the failure and take necessary corrective action. Items not in compliance with this practice and referenced documents in regard to materials, dimensions, tolerances, and workmanship shall be rejected. The purchaser shall be notified within 72 h of any rejection of a production lot as determined by 14.2.

11.1.2 *Component and Material Inspection*— The manufacturer is responsible for ensuring that components and materials used are manufactured, examined, and tested in accordance with the requirements of the referenced documents.

12. Product Assurance Testing

12.1 *Process Control, Flatwise Tensile Strength Test*—Specimens, cut from the process control panel (see 10.1), shall be tested in accordance with Test Method C297/C297M. The specimens shall be tested at a temperature of 23 ± 3°C (73 ± 5.4°F), and at a relative humidity of 50 ± 2 %.

13. Inspection of Facilities and Equipment

13.1 *Inspection*—Facilities and equipment shall be inspected to determine conformance with the requirements in Sections 5 and 6, respectively.

13.2 *Calibrations, Temperature, and Pressure Requirements, and Controls*—Calibrations, temperature, and pressure requirements and the procedures to be followed for their measurement and control during the production of shelter panels shall be as specified in 6.1.1 and shall be furnished at the intervals required by this practice.

14. Intermediate Testing

14.1 *Test for Core Moisture and Volatiles*—A sample of core representing the conditioned core material shall be of the nominal core thickness and have an area of at least 90 000 mm^2 (140 $in.^2$). The mass of the sample shall be determined to within 0.1 % before, W_i, and after, W_f, oven-drying. The sample shall be dried in a ventilated oven at not less than 82°C (180°F) nor more than 100°C (212°F) for honeycomb and balsa until the loss in mass in a 4-h period does not exceed 0.1 % of the mass or as specified in the shelter specification. Other core materials must meet the requirements of the shelter specification. The volatile content, V, of the conditioned sample shall be calculated as a percent of its oven dry mass using the following equation:

$$V = (W_i - W_f)/W_f(100) \quad (1)$$

14.2 *Process Control Test*—The process control specimens specified in 10.1 shall be tested as specified in 12.1. Failure to meet any test requirements shall require a failure analysis by the manufacturer and a retest of a second set of specimens representative of that lot. A failure in the retest shall be cause for rejection of the production lot of panels.

14.3 *Inspection and Test of Shelter Panels:*

14.3.1 *Visual Inspection of Panels*—Each bonded panel shall be visually inspected for defects. Each panel having a

bulge or depression with an area greater than 5000 mm^2 (8 $in.^2$) and with a deviation from flatness greater than 1.5 mm (1/16 in.) shall be rejected. Deviation from flatness shall be measured with a 1.2 m (48 in.) long straightedge and thickness gage as described in 14.3.2.

14.3.2 *Dimensional and Flatness Inspection of Panel*—After the bonded panels have cooled to the ambient temperature, each panel shall be inspected for overall dimensions and bowing. The dimensions shall conform to the requirements of 9.1. The panel shall be inspected for flatness by use of a straightedge placed along the diagonal while the panel is supported on a flat surface. Panels found to be bowed in excess of the limit given in the shelter specification shall be rejected.

14.3.3 *Nondestructive Testing*—Subject to approval by the purchaser, each bonded panel shall be inspected for disbond areas by either ultrasonic thru-transmission (two transducer squirter system), transducer resonance, sonic tap testing, or acoustic ultrasonic (dry contact acoustic transmission) in order to ensure that the requirements of 10.2 are met. If the sonic tap testing technique is chosen, the panel shall be tap tested in each 150 × 150 mm (6 × 6 in.) square of panel surface area using light tapping blows for best results. The tapping procedure and tap hammer shall conform to the requirements of MIL-Handbook 337.

15. Certification

15.1 At the request of the purchaser in the contract or order, a manufacturer's certification shall be provided indicating that the panels complied with this practice.

16. Keywords

16.1 adhesive bonding; composite facing; core; relocatable shelters; sandwich panels; shelter; surface preparation

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