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Standard Practice for Adhesive Bonding of Aluminum Facings to Nonmetallic Honeycomb Core for Shelter Panels¹

This standard is issued under the fixed designation E874; 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 describes the materials, processes, and quality controls to be used in the manufacture of adhesive-bonded, aluminum-faced, nonmetallic-honeycomb-core sandwich panels for tactical shelters.

1.2 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.

1.3 *This standard does not purport to address 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

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

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

D1781 Test Method for Climbing Drum Peel for Adhesives

E864 Practice for Surface Preparation of Aluminum Alloys to Be Adhesively Bonded in Honeycomb Shelter Panels

E865 Specification for Structural Film Adhesives for Honeycomb Sandwich Panels

E866 Specification for Corrosion-Inhibiting Adhesive Primer for Aluminum Alloys to Be Adhesively Bonded in Honeycomb Shelter Panels

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

E1091 Specification for Nonmetallic Honeycomb Core for Use in Shelter Panels

~~E1826 Specification for Low Volatile Organic Compound (VOC) Corrosion-Inhibiting Adhesive Primer for Aluminum Alloys to Be Adhesively Bonded~~ Specification for Low Volatile Organic Compound (VOC) Corrosion-Inhibiting Adhesive Primer for Aluminum Alloys to Be Adhesively Bonded

E2004 Test Method for Facing Cleavage of Sandwich Panels

2.2 Military Standards:³

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

2.3 Federal Standards:³

Fed. Std. No. 209 Clean Room and Work Station Requirements, Controlled Environment

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *excessive corrosion, n*—surface corrosion that is not removed by cleaning as described in Practice E864.

3.1.2 *gouge, n*—a surface defect in which material has been removed and that causes a decrease in strength in a highly stressed area.

3.1.3 *nominal pressure, n*—the intended operating pressure.

3.1.4 *nominal temperature, n*—the intended operating temperature.

¹ This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.53 on Materials and Processes for Durable Rigidwall Relocatable Structures.

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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>.

3.1.5 *tapping test, n*—a nondestructive evaluation procedure for detecting panel delamination in which the outer skin of the panels is tapped with a hammer or coin.

3.1.5.1 *Discussion*—Changes in acoustic emissions resulting from tapping can be associated with delamination and nondelaminated sections of panel.

4. Significance and Use

4.1 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, and the performance of the steps in the bonding process. Experience has shown that adhesive bonding carried out in accordance with this practice produces relatively reproducible bonds.

5. Facilities

5.1 *Panel-Assembly-Layup Area*—The panel-assembly-lay-up area is an enclosed, environmentally controlled area that is continuously controlled for temperature, relative humidity, and concentration of airborne particles. The environmentally controlled area shall be maintained at a temperature of $75 \pm 10^\circ\text{F}$ ($24 \pm 6^\circ\text{C}$) 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 environmentally controlled area. The filters shall ensure that the particle count within the environmentally controlled area will not exceed 200 000 particles/ft³ (7×10^6 particles/m³) of size 1 μm and larger. The air pressure differential between the environmentally controlled area and adjacent areas shall be monitored continuously and recorded at least twice weekly. The air pressure in the environmentally controlled area shall be maintained above that of adjacent areas by a minimum of 0.015 in. H₂O (3.7 Pa). The particle count shall be monitored in accordance with Fed. Std. No. 209. The recorders shall be calibrated every six months. The environmentally controlled area shall be conspicuously identified at all entrances as *limited access*. Unnecessary traffic within the environmentally controlled area shall not be permitted. Eating and smoking within the environmentally controlled area shall not be permitted and the environmentally controlled area shall be so posted. All materials, tools, and equipment used in the environmentally controlled area shall be clean, low shed, and free of lint, oil, and grease. The application of oil, grease, mold release agents, or other possible contaminants within the environmentally controlled area shall be prohibited. The interior, exposed surfaces of the environmentally controlled area shall be nonshedding and easily cleaned. The floor shall be sealed and cleaned daily to minimize dust generation. No preparations such as insertion of foam into honeycomb core, or cleaning other than by filtered vacuum, shall take place in the environmentally controlled area. No core cutting shall be allowed in the environmentally controlled area other than that required for integral-panel cutouts involving total thickness of the core to precut skin openings, core repair, or minor trimming.

5.2 *Primer Application Area*—The primer-application area shall be separated from the cleaning tanks, manufacturing area, and other areas of potential contamination. All air furnished to this area shall be filtered, and compressed air used shall be oil-free.

6. Apparatus

6.1 *Pressure Equipment*—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 20 psi (138 kPa) and 300°F (150°C) over the entire panel surface. Platens shall be flat to within 0.002 in./ft (0.17 mm/m). 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 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 at 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 shall be maintained. All calibrations must be traceable to the National Institute of Standards and Technology (NIST).⁴

6.2 *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 without unnecessarily delaying production. All calibrations of test equipment required by this practice shall be traceable to NIST.

7. Materials

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

⁴ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

7.2 Aluminum:

7.2.1 *Facings*—The facings shall be aluminum alloy conforming to Specification B209 and shall be certified as complying with the alloy, temper, and thickness requirements of the shelter specification. Facings shall be free of excessive corrosion, oil canning (snap-buckling), dents, gouges, or other defects that may adversely affect the structural integrity of a bonded panel. The manufacturer's certification or reports of tests for mechanical properties and chemical composition shall be included with each shipment.

7.2.2 *Preparation of Aluminum-Alloy Parts for Bonding*—The aluminum-alloy parts used in the manufacture of honeycomb panels shall be prepared for bonding in accordance with Practice E864.

7.3 *Honeycomb Core*—The honeycomb-core material shall be as specified in the shelter specification and shall meet the requirements of Specification E1091. It shall be stored in its shipping container in a segregated area away from traffic congestion until processing for panel layup.

7.4 *Adhesives*—The structural film and core splice adhesives shall conform to Specifications E865 and E990, respectively. They shall be stored in accordance with the manufacturer's recommendation.

7.4.1 *Qualification of Adhesive System*—The panel manufacturer is responsible for ensuring that the adhesive system used in the manufacture of panels under this practice is qualified to meet Specifications E865 and E990.

7.5 *Primer*—The adhesive primer shall conform to Specification E866.

7.6 *Thermal Barriers*—Thermal barriers shall conform to the purchaser's requirements.

NOTE 1—Thermal barriers are bonded between the skin and metal-edge members to prevent a thermal short between exterior and interior skins.

8. Panel Construction

8.1 The alloy, temper, and thickness of the facings, edge closure details, core type, and the weights and sizes of the panels shall be as specified in the design specification. Panels shall not have any defects, bulges, depressions, or dents with an area greater than 8 in.² (5200 mm²) or deeper than 0.040 in. (1.0 mm). The total allowable area of defects per panel shall not exceed 0.1 % of panel area per side. Panels exceeding 0.1 % defect area may be subjected to rework procedure agreed upon between the manufacturer and the customer. Panels shall not be bowed or warped nor shall there be any deviation from total flatness of the panel greater than 0.016 in./ft (1.3 mm/m). The allowable deviation from flatness (warpage) shall be determined by applying a straight-edge, as specified in 10.6.1, against the concave side of the panel with the opposite side lying on a flat surface and measuring the maximum gap between the straightedge and the panel.

8.2 *Edge Closures and Framing Members*—These shall be as specified in the shelter-design specification. On pre-existing designs, process the material in accordance with pre-existing design configuration/specification requirements unless otherwise directed by the procuring activity. When the aluminum edge closures are to be bonded, they shall be treated in accordance with Practice E864. When the shelter design requires the edge closures and framing members to be bonded simultaneously with panels bonding, the edge closures and framing members shall be bonded to the facings with the structural film adhesive specified in 7.4.

8.3 *Preparation of Aluminum Facings and Edge Closures*—All cutting, trimming, and sizing of the facings and edge closures shall be made prior to surface preparation or on the panel following completion of the bonding operation. The faying surfaces of all aluminum parts which are to be bonded shall be prepared in accordance with Practice E864 and Specification E866 or Specification E1826. All aluminum for bonded panels shall be placed in primer application area within ½ h after completion of the cleaning process.

8.4 *Preparation of Honeycomb Core*—Honeycomb that is not to be filled with plastic foam shall be cleaned of dust with dry, oil-free, filtered, compressed air or vacuumed prior to delivery to the panel-assembly-lay-up area. When the cells of the honeycomb core are filled with plastic foam, the surface of the installed foam shall be at least ¼ in. (1.5 mm) below the surface of the honeycomb on both surfaces, and all bonding surfaces shall be freed from 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 uniformity of thickness is maintained across the seam. The core-splicing material shall conform to Specification E990 and must be impermeable to water and serve as a barrier to water migration. 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 removed 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 lay-up such that the gap between the core and the framing members is no more than 0.125 in. (3.2 mm) from the framing members. The volatile content of the honeycomb core (including moisture) at the time of panel-assembly lay-up shall not exceed 2 % by mass when tested in accordance with 10.4.2.

8.5 *Application of Primer and Adhesive*—The prepared aluminum facings and framing members shall be free of contaminants before application of the primer and the adhesive. Application of primer shall be carried out in the primer application area. Parts requiring identification shall be marked with inks or methods approved for bonding. The faying surface of each facing prior to and following the application of primer shall exhibit uniform properties as determined by Specification E866 or Specification E1826 depending upon which primer is being used. The procedures, equipment for application, and the amount of primer and adhesive applied shall be in conformance with the manufacturer's instructions or the process specification approved by the purchaser. The thickness of primer applied per unit area of facing shall be measured at least once each working shift and whenever a change of working personnel is made. Apply the primer to the clean, prepared faying surfaces within 16 h after their preparation. Primed and