



Designation: E1555 – 20

# Standard Specification for Structural Paste Adhesive for Sandwich Panel Repair<sup>1</sup>

This standard is issued under the fixed designation E1555; 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 ( $\epsilon$ ) 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 specification defines those characteristics that are required of adhesives to be used in the repair of sandwich panels for durable, rigidwall, relocatable structures.

1.1.1 This specification covers two-part epoxy adhesive suitable for bonding aluminum alloy facings to nonmetallic core, core to core, and core to perimeter aluminum extrusion frame in the repair of durable rigidwall relocatable structures. The adhesive shall be suitable for forming bonds that will withstand exposure to temperatures from  $-54^{\circ}\text{C}$  to  $93^{\circ}\text{C}$  ( $-65^{\circ}\text{F}$  to  $199^{\circ}\text{F}$ ) and high relative humidity and will also withstand the combinations of stress, temperature, and relative humidity that are expected to be encountered in service. The adhesive shall also be suitable for the bonding of panel inserts and edge attachments.

1.2 The values stated in SI units are to be regarded as standard where only SI units are given, or where SI units are given first followed by inch-pound units; where inch-pound units are given first followed by SI units, the inch-pound units are to be regarded as the standard.

1.3 The following safety hazards caveat pertains only to the test methods described in this specification. *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.*

1.4 *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.*

<sup>1</sup> This specification 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.

Current edition approved Sept. 1, 2020. Published October 2020. Originally approved in 1993. Last previous edition approved in 2012 as E1555 – 12. DOI: 10.1520/E1555-20.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

D1002 Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)

D1781 Test Method for Climbing Drum Peel for Adhesives

D2919 Test Method for Determining Durability of Adhesive Joints Stressed in Shear by Tension Loading

E4 Practices for Force Verification of Testing Machines

E631 Terminology of Building Constructions

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

E1091 Specification for Nonmetallic Honeycomb Core for Use in Shelter Panels

E1749 Terminology Relating to Rigid Wall Relocatable Shelters

### 2.2 Federal Specifications:<sup>3</sup>

MIL-STD-401 Sandwich Constructions and Core Materials; General Test Methods

QQ-A-250/8d Aluminum Alloy 5052 H34 Plate and Sheet

QQ-A-250/11d Aluminum Alloy 6061 T6 Plate and Sheet

## 3. Terminology

3.1 *Definitions*—For definitions of general terms related to building construction used in this specification, refer to Terminology E631, and for general terms related to rigid wall relocatable shelters, refer to Terminology E1749.

## 4. Material

4.1 The adhesive shall be a two-part thermosetting epoxy paste containing no asbestos and when tested using the test methods described in Section 7, shall meet the requirements of Section 5. The adhesive shall not have a deleterious effect on

<sup>2</sup> 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.

<sup>3</sup> Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111, http://quicksearch.dla.mil..

the components being bonded over the range of temperatures at which the adhesive will be used.

## 5. Physical Requirements

### 5.1 Working Characteristics:

5.1.1 *Application*—The adhesive shall be suitable for application to facings and core materials. The adhesive shall not drip and shall not develop an overall average sag of 6.3 mm (0.25 in.) or more when tested in accordance with the procedures described in 7.7.

5.1.2 *Adhesive Life*—The adhesive, when mixed in 1 qt kit quantities in a standard quart paint can, allowed to sit for 30 min at 23 °C ± 3 °C (73.4 °F ± 5.4 °F), and then used to prepare test specimens as prescribed in 7.1 – 7.3, shall still be able to deliver the lap shear property levels listed in Table 1 for the 23 °C temperature test condition.

5.1.3 The adhesive, when mixed in a quart kit and allowed to stand in ambient still air, shall not, as a result of an exothermic reaction, heat itself to a temperature of 49 °C (120 °F) or above. This shall be performed in a chemical fume hood so that heat and any potentially toxic fumes that may be released as a result of exothermic reaction are controlled. A preliminary test, using a pint kit, shall be conducted to determine if a potential problem exists.

5.1.4 *Curing*—The adhesive shall be capable of curing at 23 °C ± 3 °C (73.4 °F ± 5.4 °F) in 7 days, or for no longer than 3 h at a temperature of 60 °C to 66 °C (140 °F to 150.8 °F), with a curing pressure not to exceed 14 psig. In a 23 °C ± 3 °C (73.4 °F ± 5.4 °F) cure, the curing pressure shall also be a maximum of 14 psig and shall only be required during the first 24 h of cure. In a 23 °C ± 3 °C (73.4 °F ± 5.4 °F) cure, the adhesive shall be capable of developing 3.45 MPa (500 psi) lap shear strength, when tested at 23 °C temperature, within the first 24 h of cure.

5.1.5 *Mix Ratio*—The mix ratio for the two parts of the adhesive shall be defined by the manufacturer but shall be in the range from 10:1 to 1:1 by weight.

5.2 *Storage Life*—The storage life of the two parts of the adhesive, from date of shipment, when stored in airtight containers at 23 °C ± 3 °C (73.4 °F ± 5.4 °F), shall be at least 12 months. The adhesive shall be considered to have met this storage life requirement if all the characteristics described in 5.1 and 5.3 are met by the adhesive after the 12-month storage period described above.

5.3 *Mechanical Properties*—The mechanical properties of the adhesive, when cured for 3 h at 63 °C ± 3 °C (145.4 °F ± 5.4 °F) or 7 days at 23 °C ± 3 °C (73.4 °F ± 5.4 °F) at a cure pressure not to exceed 14 psig, shall meet the requirements of Tables 1-4.

## 6. Significance and Use

6.1 Adhesives used in the repair of sandwich panels for durable, rigidwall, relocatable structures must have a combination of mechanical property levels and environmental resistance that will ensure long-term durability of the adhesive bonds when exposed to severe climatic exposures. In addition, these adhesives must have processability characteristics that permit their use in a variety of repair scenarios and environments.

6.2 This specification defines those characteristics that are required of adhesives to be used in the repair of sandwich panels for durable, rigidwall, relocatable structures.

## 7. Test Methods

7.1 *Preparation of Test Specimens*—The adherends shall be either 6061 T6 or 5052 H34 aluminum alloy (Federal Specifications QQ-A-250/11d or QQ-A-250/8d, respectively, or Specification B209) and shall be cleaned as prescribed in Practice E864.

7.2 *Apparatus*—The testing machine shall conform to the requirements of Practices E4. The load range shall be selected so that the maximum loads for each type of test conducted falls between 15 and 85 % of the full-scale capacity. Autographic equipment, or equipment that will produce equivalent accuracy, shall be used to record loads.

7.3 *Lap-Shear Strength*—The lap shear tests shall be performed in accordance with Test Method D1002 and at the test conditions listed in Table 1. In all tests the test chamber shall be stabilized at the test temperature for 45 min prior to the test and before the specimens are placed in it.

7.3.1 *Reduced and Elevated Temperature Tests*—For the test to be conducted on specimens that have not been humidity-aged, bring the specimens to the test temperature, as indicated by a thermocouple at the bond area, and stabilize for 10 min just prior to test.

7.3.2 *Elevated Temperature Test after Humidity Aging*—The specimen shall be maintained in the humid environment until immediately before insertion into the test chamber. The specimen shall be inserted into the test chamber and the chamber temperature returned to the test temperature as rapidly as

**TABLE 1 Tensile Lap Shear (Test Method D1002)**

Test Condition <sup>A</sup>		Number of Specimens to be Tested	Average Must Exceed		Minimum Must Exceed <sup>B</sup>	
°C	(°F)		MPa	(psi)	MPa	(psi)
-54 ± 3	(-65 ± 5)	6	13.8	(2000)	11.7	(1700)
23 ± 3	(73 ± 5)	6	17.9	(2600)	15.2	(2200)
60 ± 3	(140 ± 5)	6	16.5	(2400)	14.1	(2050)
93 ± 3	(199 ± 5)	6	10.3	(1500)	8.6	(1250)
60 ± 3	(140 ± 5)	6	8.3	(1200)	7.0	(1020)

<sup>A</sup> After 30 day exposure to 60 °C ± 3 °C (140 °F ± 5 °F) and 95 to 100 % relative humidity.

<sup>B</sup> All specimens tested must exceed these minimum values.

**TABLE 2 Flatwise Tension (Specification E1091)**

Test Condition		Number of Specimens to be Tested	Average Must Exceed		Minimum Must Exceed <sup>A</sup>	
°C	(°F)		MPa	(psi)	MPa	(psi)
-54 ± 3	(-65 ± 5)	6	2.11	(306)	1.79	(260)
23 ± 3	(73 ± 5)	6	2.11	(306)	1.79	(260)
60 ± 3	(140 ± 5)	6	1.56	(226)	1.33	(192)

<sup>A</sup> All specimens tested must exceed these minimum values.

**TABLE 3 Climbing Drum Peel (Test Method D1781)**

Test Condition		Number of Specimens to be Tested	Average Must Exceed		Minimum Must Exceed <sup>A</sup>	
°C	(°F)		N-m/m	(in.-lb/in.)	N-m/m	(in.-lb/in.)
-54 ± 3	(-65 ± 5)	6	18	(4.04)	15.3	(3.4)
23 ± 3	(73 ± 5)	6	36	(8.08)	30.6	(6.8)
60 ± 3	(140 ± 5)	6	24	(6.06)	22.7	(5.1)

<sup>A</sup> All specimens tested must exceed these minimum values.

**TABLE 4 Durability Test (Test Method D2919)**

Test Condition	Number of Specimens to be Tested	Applied Stress		Average Time to Failure to Exceed
		MPa	(psi)	
60 °C ± 3 °C (140 °F ± 5 °F) and 95 to 100 % R.H.	6	8.3	(1200)	400 h
	6	11.0	(1600)	50 h

7.7.1 *Materials Required*—The following materials are required to carry out the sag test:

7.7.1.1 Aluminum test panel conforming to dimensions shown in Fig. 1a, solvent cleaned, and having lightly scribed lines located as shown in Fig. 1a,

7.7.1.2 Aluminum screeding templates, conforming to dimensions shown in Fig. 2, and

7.7.1.3 Notched rack to hold test panels in vertical position.

7.7.2 *Application of Adhesive to Test Panel*—Using a suitable applicator, apply 3 g of freshly mixed adhesive to the rectangular area of the aluminum test panel outlined by the light scribe lines. Spread this uniformly over the rectangular area, ensuring that the adhesive extends to or slightly beyond the edges of the rectangle. Avoid incorporating voids into this adhesive test patch. Draw the vertical screeding template,

possible to minimize specimen dryout. Based on the thermocouple located at the bond area, commence the test 2 min after the thermocouple returns to the test temperature.

7.4 *Flatwise Tensile Strength*—Sandwich specimens shall be prepared using nonmetallic honeycomb core meeting the requirements of Specification E1091, Type IV. The specimens shall have an area of 58 cm<sup>2</sup> (9 in.<sup>2</sup>) and be tested in accordance with the requirements in MIL-STD-401. The facing skins shall be a minimum of 0.51 mm (0.020 in.) thick. The adhesive layer between the facing skins and the honeycomb core shall be uniformly applied at a rate of 0.0488 gm/cm<sup>2</sup> (0.1 lb/ft<sup>2</sup>).

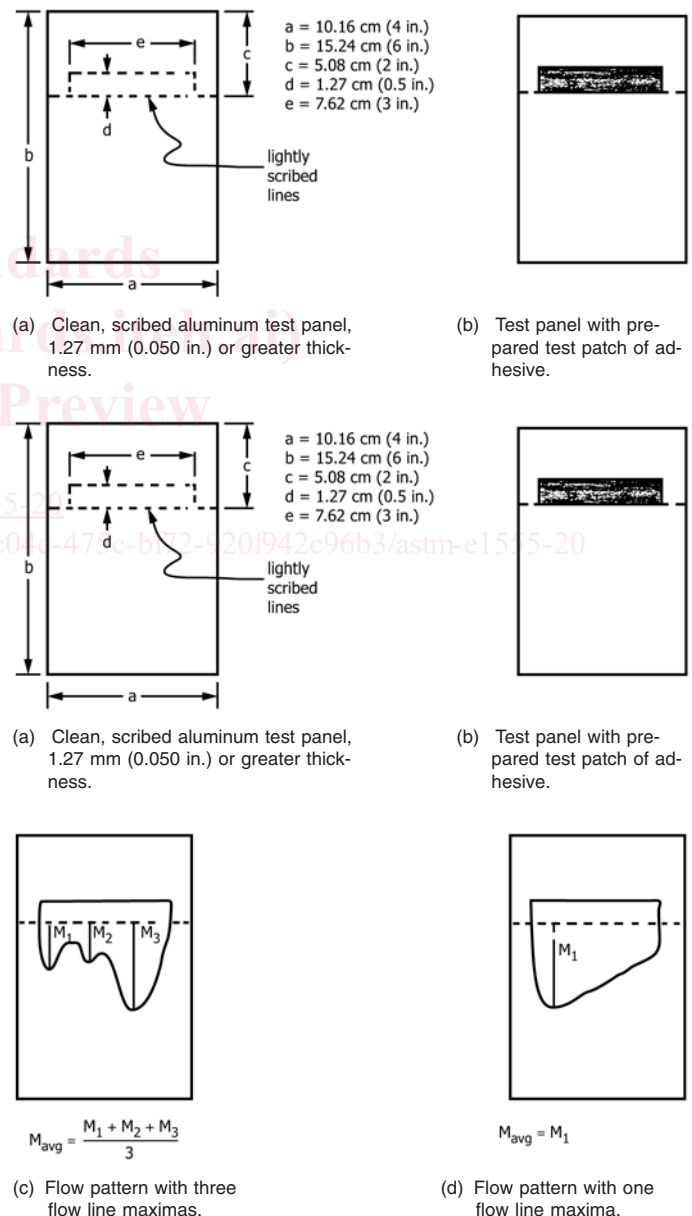
7.4.1 *Reduced and Elevated Temperature Tests*—Stabilize the chamber used to test the specimens at the test temperature for 45 min prior to the test and before the specimens are placed in it. Bring the specimens to the required test temperature, as indicated by a thermocouple at the bond area, and stabilize for 10 min just prior to test.

7.5 *Climbing Drum Peel Strength*—Sandwich specimens shall be prepared using nonmetallic honeycomb core meeting the requirements of Specification E1091, Type IV. The specimens shall be of the dimensions specified and tested in accordance with the requirements in Test Method D1781. The peeling face skin shall be 6061 T6 (QQ-A-250/11d) or 5052 H34 (QQ-A-250/8d) aluminum alloy, 0.51 mm (0.020 in.) thick. The adhesive is to be uniformly applied on each skin of the sandwich construction at a rate of 0.0488 gm/cm<sup>2</sup> (0.1 lb/ft<sup>2</sup>).

7.5.1 *Reduced and Elevated Temperature Tests*—Repeat 7.4.1.

7.6 *Dead Load Stress Durability*—Test the specimens in accordance with Test Method D2919. Maintain the conditions of the test chamber at 60 °C ± 3 °C (140 °F ± 5.4 °F) and 95 to 100 % relative humidity.

7.7 *Sag*—Sag shall be defined as the average length of the adhesive flow line maxima down a vertical plate when tested at 23 °C ± 3 °C (73.9 °F ± 5.4 °F) in the manner described below.



**FIG. 1 Illustration of Sag Test Specimen**