



Designation: **E1091–13 E1091 – 21**

Standard Specification for Nonmetallic Honeycomb Core for Use in Shelter Panels¹

This standard is issued under the fixed designation E1091; 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 specification is for nonmetallic honeycomb core used in the manufacture of adhesively bonded sandwich panels for tactical shelters. The materials are intended for adhesive bonding to aluminum facings using materials and processes defined by Practices **E864** and **E874**, and Specifications **E865**, **E866**, and **E990**. This specification covers five main types of honeycomb for use in sandwich panels, Types I, II, III, IV, and V. Types I, II, and III honeycombs correspond to three honeycomb densities. Types IV and V are similar to Types II and III, respectively, but have lower performance requirements.

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. For conversion of quantities in various systems of measurement to SI units, refer to Practice **E380**.

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, 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.*

2. Referenced Documents

2.1 ASTM Standards:²

- B209** Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- C177** Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- C366/C366M** Test Methods for Measurement of Thickness of Sandwich Cores
- C481** Test Method for Laboratory Aging of Sandwich Constructions
- C518** Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- E380** Practice for Use of the International System of Units (SI) (the Modernized Metric System) (Withdrawn 1997)³
- E631** Terminology of Building Constructions
- 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

¹ 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.

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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](http://www.astm.org) Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

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

E874 Practice for Adhesive Bonding of Aluminum Facings to Nonmetallic Honeycomb Core for Shelter Panels

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

E1749 Terminology Relating to Rigid Wall Relocatable Shelters

F501 Test Method for Aerospace Materials Response to Flame, with Vertical Test Specimen (for Aerospace Vehicles Standard Conditions) (Withdrawn 1998)³

2.2 Federal Aviation Regulation:⁴

FAR 25.853(a) Compartment Interiors

2.3 Federal Standards:⁵

FED-STD-191A Textile Test Methods

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

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

2.4 Military Standards:⁵

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

MIL-STD-129 Marking for Shipment and Storage

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

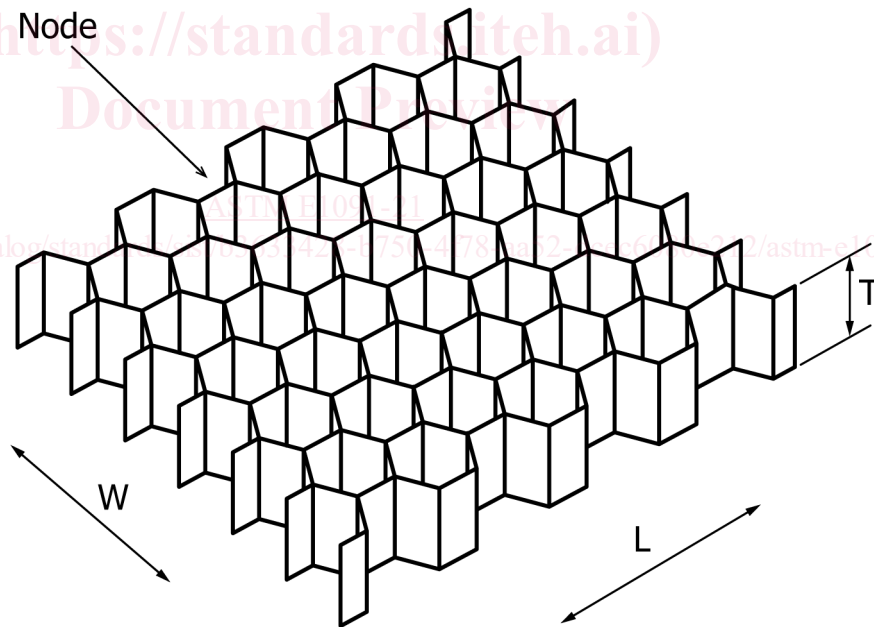
2.5 TAPPI Standard:⁶

T 435-SU-68 Test Method for Hydrogen Ion Concentration of Paper Extracts, Hot Extraction Method

2.6 Other Publications:

Uniform Freight Classification⁷

National Motor Freight Classification⁸



L— Ribbon direction or longitudinal direction of core
W— Expanded direction or transverse direction of core
T— Core thickness or depth
N— Node is the bonded portion of the honeycomb flat sheet material; the honeycomb cell's double wall

FIG. 1 Orientation of Cells in Honeycomb-Core Material

⁴ Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, <http://www.faa.gov>.

⁵ Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil/>.

⁶ Available from Technical Association of the Pulp and Paper Industry (TAPPI), 15 Technology Parkway South, Norcross, Suite 115, Peachtree Corners, GA 30092, <http://www.tappi.org>.

⁷ Available from National Railroad Freight Committee (NRFC)—RAILINC, 7001 Weston Parkway, Suite 200, Cary, NC 27513-27513, <https://public.railinc.com/>.

⁸ Available from National Motor Freight Traffic Association, Inc. (NMFTA), 1001 N. Fairfax St., Suite 600, Alexandria, VA 22314-1798, <http://www.nmfta.org>.

3. Terminology

3.1 *Definitions*—See Terminologies [E631](#) and [E1749](#) for definitions of terms used in this specification.

3.1 *Definitions:*

3.1.1 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](#).

3.2 *Descriptions/Definitions of Terms Specific to This Standard:*

3.2.1 *block, n*—a single production unit of honeycomb before slicing.

3.2.2 *cell size, n*—the average distance between node bonds, measured along the *W* direction ([Fig. 1](#)), for at least 60 cells, selected at random in groups containing 10 adjacent cells.

3.2.3 *core material, n*—a slice or sheet cut from a production block that is used in a honeycomb sandwich panel. The orientation of the cells in the honeycomb core material as produced is shown in [Fig. 1](#). The honeycomb core materials exhibit anisotropic behavior, therefore the following notation is used:

L = ribbon direction or longitudinal direction of core,

W = expanded direction or transverse direction of core,

T = core thickness or depth, and

N = bonded portion of the honeycomb flat sheet material; the honeycomb cell's double wall.

3.2.4 *first article, n*—a sample sheet of honeycomb from the first lot produced.

3.2.5 *lot, n*—1000 ft³ (28.3 m³) or less of honeycomb of the same type produced during consecutive operating or working days using the same basic materials and operating conditions.

3.2.6 *sheet, n*—a slice of honeycomb cut from a production block.

4. Classification

[ASTM E1091-21](#)

<https://standards.iteh.ai/catalog/standards/sist/b3633428-b750-4f78-aa52-dcec6080e212/astm-e1091-21>

4.1 Five types of nonmetallic honeycomb material are specified. Their required properties are given in Section 6 and in [Table 1](#).

5. Ordering Information

5.1 *Procurement Documents*—Purchasers shall select any of the desired options offered herein and the procurement documents shall specify the following:

5.1.1 Title, number, and date of this specification.

5.1.2 Type of honeycomb required (see [Section 4](#)).

5.1.3 Dimensions required (see [6.4](#)).

5.1.4 Cell size required (see [6.2](#) and [6.4](#)).

5.1.5 Whether a first article sample is required (see [3.3](#)).

5.1.6 Whether qualification is necessary (see [8.2.2](#)).

5.2 When a first article sample is required, specific instructions shall be given regarding arrangements for examination, test, and approval of the first article.

TABLE 1 Honeycomb-Core Material Properties

Type	Type I	Type II	Type III	Type IV	Type V
Maximum density, lb/ft ³ (kg/m ³)	5.5 (88)	4.4 (70)	3.3 (53)	4.4 (70)	3.3 (53)
pH, pH units	7.0 ± 0.5	7.0 ± 0.5	7.0 ± 0.5	6.0 ± 0.5	6.0 ± 0.5
Compressive strength,^A psi (MPa):					
Dry, min ^B	464 (3.20)	464 (3.20)	232 (1.60)	404 (2.79)	198 (1.37)
Wet, min ^C	406 (2.80)	232 (1.60)	116 (0.80)	163 (1.13)	98 (0.68)
At elevated temperature ^D	394 (2.72)	278 (1.92)	139 (0.96)	185 (1.28)	115 (0.79)
Cyclic aging, minimum	363 (2.50)	190 (1.31)	104 (0.72)	119 (0.82)	62 (0.43)
After fungus test ^E			See Footnote E		
Shear strength,^A psi (MPa):					
Dry, min					
TL core orientation ^B	218 (1.50)	218 (1.50)	116 (0.80)	180 (1.24)	85 (0.59)
TW core orientation ^B	130 (0.90)	116 (0.80)	65 (0.45)	113 (0.78)	57 (0.39)
Wet, min					
TL core orientation ^C	203 (1.40)	109 (0.75)	58 (0.40)	86 (0.59)	53 (0.37)
TW core orientation ^C	116 (0.80)	58 (0.40)	33 (0.23)	58 (0.40)	32 (0.22)
Flatwise tensile strength, min,^F :					
psi (MPa)	406 (2.80)	406 (2.80)	231 (1.60)	306 (2.11)	231 (1.60)
Brittleness/Impact:					
Drop height, min, in. (mm)	40 (1016)	30 (762)	20 (508)	30 (762)	20 (508)
Water migration resistance:					
24 h, max, number of cells	3	3	3	3	3

^A Two-inch (51 mm) thick core with 0.05 in. (1.3 mm) facings, tested at 73 ± 2°F (23 ± 1°C) unless otherwise stated herein. Shear tests shall be conducted with the core oriented in the TL and TW planes (Fig. 1).

^B At equilibrium with 73 ± 2°F (23 ± 1°C), 73 °F ± 2 °F (23 °C ± 1 °C), and 50 ± 4 % RH.

^C After soaking in water at 70 ± 5°F (21.1 ± 3°C) for 48 h with perforated facings.

^D After heating for 30 min at, and tested at, 176 ± 5°F (80 ± 3°C).

^E Values for compressive strength shall be not less than 85 % of the dry compressive strength values for Types I, II, and III and 80 % for Types IV and V.

^F Tested at 73 ± 2°F (23 ± 1°C) with loading blocks bonded directly to each side of core specimen having a minimum area of 9 in.² (5806 mm²).

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6. Materials and Manufacture

6.1 **Materials**—Materials shall be as specified herein for the type ordered and shall comply with all provisions of this specification for this type.

6.2 **Configuration**—The honeycomb material (see Fig. 1) shall consist of a nonmetallic web material, suitably bonded so that in its final expanded form, a reasonably uniform cellular shape is developed. Unless otherwise specified, the cell size shall not exceed 0.5 in. (12.5 mm).

6.3 **Flame Resistance**—The honeycomb core material shall meet the following requirements when tested as specified:

6.3.1 Average burn rate shall not exceed 4 in./min.

6.3.2 Self extinguishment within 15 s after removal of the ~~60~~s60 s applied flame.

6.3.3 Burning without flame shall not extend into undamaged area of core material.

6.4 **Dimensions**—Using the methods specified in 7.15, the length, width, and thickness dimensions of the honeycomb core (see Fig. 1) and the cell size shall be as specified.

6.5 **Dimensional Tolerances**—Unless otherwise specified, the dimensional tolerances of the honeycomb core material shall be as specified in Table 2. The cell size shall not vary more than 10 % from the specified dimension within any lot.

TABLE 2 Dimensional Tolerances

Dimensions	Tolerance, in. (mm)	
	plus	minus
Length	2.0 (50.8)	0 (0)
Width	1.0 (25.4)	0 (0)
Thickness	0.010 (0.254)	0.010 (0.254)

6.6 *Unbonded Nodes*—There shall be no more than one unbonded node within any ~~10 in.~~ 10 in. by ~~10 in.~~ 10 in. (~~250 mm by 250 mm~~) 250 mm area of the honeycomb core.

6.7 *Honeycomb Properties:*

6.7.1 *Physical and Mechanical*—The physical and mechanical properties of the honeycomb material shall meet the requirements listed in **Table 1** when tested using the methods specified.

6.7.2 *pH*—When tested as specified, the pH of the honeycomb material shall meet the requirements listed in **Table 1**.

6.7.3 *Fungus Resistance*—When the fungus resistance is determined as specified, the compressive strength of the honeycomb shall meet the requirements listed in **Table 1**.

6.8 *Density*—The density of the honeycomb material, determined as specified, shall not exceed the values shown in **Table 1** and shall be within $\pm 10\%$ of the manufacturer's specified density.

6.9 *Workmanship*—The honeycomb core material shall be free of excess resin accumulations (for example, runs and sags), starved areas (for example, lack of resin), and foreign materials. The cell wall edges of the core shall be clean cut with no broken edges.

6.10 *Thermal Resistance*—At the request of the purchaser, the thermal resistance, determined as specified, shall be reported.

6.11 *Shear Modulus and Compressive Modulus*—At the request of the purchaser, the honeycomb shear modulus and compressive modulus, determined as specified, shall be reported.

7. Test Methods

7.1 *Test Specimens*—Unless otherwise specified, test specimens shall be bonded at the same temperature, cure time, and pressure profiles as used in actual shelter panel manufacture and conditioned and tested under standard conditions of $73 \pm 2^\circ\text{F}$ ($23 \pm 1^\circ\text{C}$) $73^\circ\text{F} \pm 2^\circ\text{F}$ ($23^\circ\text{C} \pm 1^\circ\text{C}$) and $50 \pm 4\%$ $50\% \pm 4\%$ relative humidity (RH). (See Specification **E865**.)

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7.2 *Density*—Test the density of the honeycomb material for compliance with the requirements given in **Table 1**. Determine the density using the core density method of MIL-STD-401 using two specimens, each at least 2.2 ft² (0.2 m²) in area. Condition the specimens as specified for at least 48 h. Record each individual density value. Determine the average density value of the two specimens. The test is failed if any average density value does not meet the requirements of **Table 1** and **6.8**.

7.3 *Honeycomb Core Shear*—The *L* by *W* by *I* dimensions of the bonded sandwich specimens shall be ~~15 in.~~ 15 in. by ~~33 in.~~ 33 in. by 2 in. (~~380(380 mm by 7575 mm~~ by 50 mm). The skin shall consist of ~~0.05 in.~~ 0.05 in. (~~1.3 mm~~) 1.3 mm thick perforated sheet of 5052H34 or 6061T6 aluminum alloy. The perforated holes shall be 0.13 in. (3.2 mm) in diameter with 0.19 in. (4.8 mm) staggered centers. The adhesive used for bonding the specimen shall conform to Specification **E865**.

7.3.1 *Wet*—Soak twelve specimens under a ~~12 in.~~ 12 in. (3.0 kPa) head of water at $70 \pm 5^\circ\text{F}$ ($21 \pm 3^\circ\text{C}$) $70^\circ\text{F} \pm 5^\circ\text{F}$ ($21^\circ\text{C} \pm 3^\circ\text{C}$) for at least 48 h. When perforated skins are bonded to the core, clear the perforations of adhesive so that there is at least one hole into each cell through each skin. After removal from the water, shake the bonded specimens to remove excess water. Then test the bonded specimens in accordance with the Sandwich Flexure test method of MIL-STD-401 using a ~~12 in.~~ 12 in. (~~305 mm~~) 12 in. (305 mm) span, 2-point loading system consisting of ~~22 in.~~ 22 in. by ~~33 in.~~ 33 in. by 0.25 in. (~~50(50 mm by 7575 mm~~ by 6 mm) loading blocks on $\frac{1}{3}$ span. Test six bonded specimens with the core oriented in the TL plane (**Fig. 1**) and six with the core oriented in the TW plane (**Fig. 1**). Record all individual shear strength values for each plane. The test is failed if two or more of the six values of each plane do not meet the requirements of **Table 1** or the average value is below **Table 1**.

7.3.2 *Dry*—Condition twelve specimens as specified in **7.1** for at least 48 h, then test as described in **7.3.1**. At the option of the supplier, the skins specified in **7.3** do not necessarily have to be perforated. Record all individual shear strength values for each plane. The test is failed if two or more of the six values for each plane do not meet the requirements of **Table 1** or the average value is below **Table 1**.

7.4 Honeycomb Core Compression—The *L* by *W* by *T* dimensions of the bonded sandwich specimens shall be ~~44 in.~~ by ~~44 in.~~ by 2 in. (~~100 mm~~ by ~~100 mm~~ by 50 mm). The skin shall consist of ~~0.05 in. (1.3 mm)~~ 0.05 in. (1.3 mm) thick perforated sheet of 5052H34 or 6061T6 aluminum alloy (Federal Specifications QQ-A-250/8 or QQ-A-250/11) or (Specification **B209**). The perforated holes shall be 0.13 in. (3.2 mm) in diameter with 0.19 in. (4.8 mm) staggered centers. The adhesive used for bonding the specimen shall conform to Specification **E865**.

7.4.1 Wet—Soak six specimens under a ~~12 in.~~ 12 in. (3.0 kPa) head of water at ~~70 ± 5°F (21 ± 3°C)~~ 70 °F ± 5 °F (21 °C ± 3 °C) for at least 48 h. When perforated skins are bonded to the core, clear the perforations of adhesive so that there is at least one hole into each cell through each skin. After removal from the water, shake the bonded specimens to remove excess water. Then test the bonded specimens in accordance with the Core Compression Test Method of MIL-STD-401. Record all individual compressive strength values. The test is failed if two or more of the six values do not meet the requirements of **Table 1** or the average value is below the value given in **Table 1**.

7.4.2 Dry—Condition six specimens as specified in **7.1** for at least 48 h. Then test in accordance with the Core Compression Test Method of MIL-STD-401. At the option of the supplier, the skins specified do not necessarily have to be perforated. Record all individual compressive strength values. The test is failed if two or more of the six values do not meet the requirements of **Table 1** or the average value is below **Table 1**.

7.4.3 Elevated Temperature—Heat six specimens to ~~176 ± 5°F (80 ± 3°C)~~ 176 °F ± 5 °F (80 °C ± 3 °C) for a duration of 30 min and test immediately at that temperature. The test procedure shall be in accordance with the Core Compression Test Method of MIL-STD-401. At the option of the supplier, the skins do not necessarily have to be perforated. Record all individual compressive strength values. The test is failed if two or more of the six values do not meet the requirements of **Table 1** or the average value is below the value given in **Table 1**.

7.5 Honeycomb Core Cyclic Aging—Specimens shall be as specified in **7.4**. When perforated skins are bonded to the core, clear the perforations of adhesive so that there is at least one hole into each cell through each skin. Test six specimens by the Cycle A Aging Test Procedure of Test Method **C481**. Subject each specimen to ten complete cycles of laboratory aging except that the “heat” and “heat in dry air” procedures do not apply, and the time for cold storage may be reduced from 20 h to 17 h. Upon completion of the tenth cycle, shake the bonded specimens to remove excess water, store at ~~73 ± 2°F (23 ± 1°C)~~ 73 °F ± 2 °F (23 °C ± 1 °C) for 60 min. Then test in accordance with the Core Compression Test Method of MIL-STD-401. Record all individual compressive strength values. The test is failed if two or more of the six values do not meet the requirements of **Table 1** or the average value is below the value given in **Table 1**. **E1091-21**

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7.6 Honeycomb Core Brittleness Impact—The *L* by *W* by *T* dimensions of the specimens, cut from a bonded sandwich sheet, shall be ~~24 in.~~ by ~~24 in.~~ by 2 in. (~~610 mm~~ by ~~610 mm~~ by 50 mm). The adhesive used for bonding the specimen shall conform to Specification **E865**. The skins shall consist of 0.05 in. (1.3 mm) thick sheet of 5052H34 or 6061T6 aluminum alloy (Federal Specifications QQ-A-250/8 or QQ-A-250/11) or (Specification **B209**). Condition the specimen as specified in **7.1** for at least 48 h. Support the bonded specimen by, but not rigidly fixed to, a nominal ~~22 in.~~ by ~~4 in.~~ 22 in. by 4 in. (~~504 in.~~ 50 mm by ~~100 mm~~) 100 mm softwood frame resting on a flat concrete floor. Drop a steel cylinder weight, 70 lb (31.8 kg) with ~~3 in.~~ 3 in. (~~76 mm~~) 76 mm diameter hemispherical striking surface, the distance listed in **Table 1** onto the approximate center of the supported bonded specimen. Cross section the bonded test specimen through the impact area and visually examine. Any of the following shall constitute failure of this test (see **Fig. 2**):

7.6.1 Rupture of impacted or opposite skin, or both.

7.6.2 Delamination of the opposite skin to core.

7.6.3 Delamination of impacted skin to core or any crushing/collapsing of the core, or both, outside a 3 in. (76 mm) radius from the *center of impact* (which shall coincide with the approximate center of the test panel specimen).

7.6.4 Core shear failure outside a 5 in. (127 mm) radius from the *center of impact* (which shall coincide with the approximate center of the test specimen).

7.7 Flatwise Tensile—Prepare six specimens, 2 in. (50 mm) thick, each having minimum dimensions of ~~33 in.~~ by 3 in. (~~75~~ 75 mm by 75 mm), for testing by bonding loading blocks directly to each side of the core. The adhesive used shall have sufficient bonding strength to ensure failure in the core and not between the core and block. The bonding technique shall be such that it does not affect

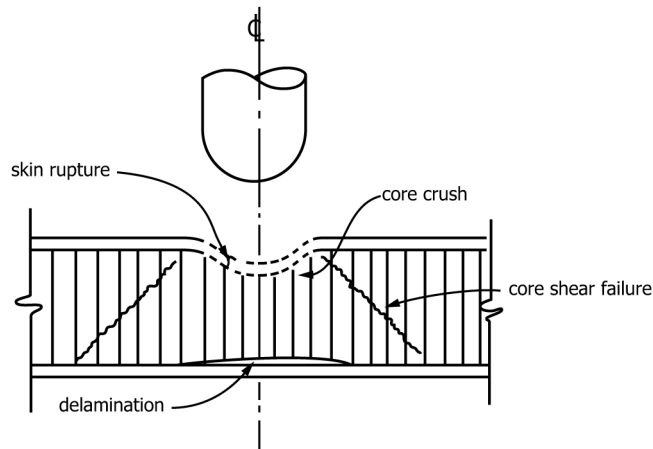


FIG. 2 Brittliness/Impact Test Failure Modes

the characteristics of the core (Note 1). Condition the bonded specimen as specified in 7.1 for at least 48 h. Then test the bonded specimens in accordance with the Sandwich Tension Test Method of MIL-STD-401. Record all individual tensile strength values. The test is failed if two or more of the six values do not meet the requirements of Table 1 or the average value is below the value given in Table 1.

NOTE 1—Epoxy resin adhesives have been found useful for bonding the loading blocks at room temperature or at slightly elevated temperature.

7.8 pH—The pH of the honeycomb material shall be determined by T 435-SU-68.

7.9 Fungus Resistance:

7.9.1 Twenty specimens of bare honeycomb material are required. The L by W by T dimensions of the specimens shall be 44 in. by 44 in. by 2 in. (± 0.0100 mm by ± 0.0100 mm by 50 mm). All twenty specimens shall have the cell ends reinforced in accordance with the specimen preparation procedures of the Core Compression Test Method of MIL-STD-401. Retain ten of these specimens as control specimens and expose ten to the Mildew Resistance, Soil Burial Test Method 5762 of FED-STD-191A for a period of 28 days except as follows:

7.9.1.1 The number of specimens shall be ten.

7.9.1.2 The specimens shall be buried in the soil with the honeycomb cells perpendicular to the surface such that the cells are filled with soil.

7.9.2 After exposure, condition the ten fungus test specimens, as well as the ten control specimens, as specified in 7.1 for at least 48 h. Then test in accordance with the Core Compression Test Method of MIL-STD-401. At least nine compressive strength values for the ten control specimens and the average compressive strength of all specimens shall meet the dry compression values shown in Table 1. At least seven of the ten specimens subjected to the fungus test shall meet 85 % of the average compressive strength values obtained from the Type I, II, or III control specimens but 80 % of the average compressive strength values obtained from Type IV and V control specimens.

7.10 Thermal Resistance—Test three full-use thickness (T dimension) of the bare honeycomb material for thermal resistance in accordance with Test Method C518 or Test Method C177 and record the results as specified.

7.11 Shear Modulus—Test three dry specimens of honeycomb material with the core oriented in each of the TL and TW planes (Fig. 1) for shear modulus. Determine the shear modulus in accordance with the Core Shear Test Method of MIL-STD-401 and record as specified.

7.12 Core Compressive Modulus—Test three dry specimens of honeycomb material for compressive modulus. Determine the compressive modulus in accordance with the Core Compression Test Method of MIL-STD-401 and record as specified.