



Standard Test Method for Dimensional Stability of Sandwich Core Materials¹

This standard is issued under the fixed designation D6772/D6772M; 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.

1. Scope

1.1 This test method covers the determination of the sandwich core dimensional stability in the two plan dimensions.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.2.1 Within the text, the inch-pound units are shown in brackets.

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

D2711/C2711M Test Method for Density of Sandwich Core Materials

D883 Terminology Relating to Plastics

D3878 Terminology for Composite Materials

D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

¹ This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.09 on Sandwich Construction.

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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. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites, as well as terms relating to sandwich constructions. Terminology D883 defines terms relating to plastics. Terminology E456 and Practice E177 define terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other terminologies.

3.2 *Symbols:*

3.2.1 CV —coefficient of variation statistic of a sample population for a given property (in percent)

3.2.2 L_i —initial (pre-test) measured dimension

3.2.3 L_f —post-heating measured dimension

3.2.4 S_{n-1} —standard deviation statistic of a sample population for a given property

3.2.5 x_f —test result for an individual specimen from the sample population for a given property

3.2.6 \bar{x} —mean or average (estimate of mean) of a sample population for a given property

4. Summary of Test Method

4.1 This test method consists of placing a small piece of sandwich core material in an elevated temperature environment for a specified period of time. After cooling, the dimensional changes in the planar dimensions are measured and compared to the initial measurements taken prior to thermal exposure, both immediately after heating and after re-conditioning. A typical honeycomb core specimen is shown in Fig. 1.

5. Significance and Use

5.1 Sandwich panel cores may change planar dimensions when heated. This phenomenon can be associated with the effects of heating upon the core material itself, as well as changes in core moisture content resulting from the heating cycle. It is prudent to know if this may be problematic with regard to the intended final part dimensions.

5.2 This test method provides a standard method of characterizing the dimensional stability of sandwich core materials for design properties, material specifications, research and development applications, and quality assurance.

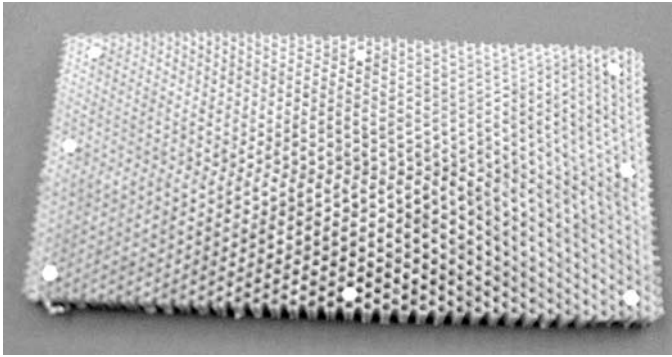


FIG. 1 Dimensional Stability Specimen

5.3 Factors that influence dimensional stability of sandwich core materials and shall therefore be reported include the following: core material, methods of material fabrication, core geometry, core thickness, core thickness uniformity, cell wall thickness, specimen geometry, specimen preparation, heating and cooling environments (including temperatures and humidity levels), and specimen conditioning (both prior to and after heating).

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices and damage induced by improper specimen machining are known causes of high data scatter for sandwich cores. Important aspects of sandwich core specimen preparation that contribute to data scatter include the existence of joints, voids or other core discontinuities, out-of-plane curvature, and surface roughness.

6.2 *Core Geometry*—Core-specific geometric factors that affect dimensional stability include core cell size, uniformity of core cell geometry, core cell wall thickness, core cell wall thickness uniformity, core thickness, and core thickness uniformity.

6.3 *Environment*—Results are affected by the environmental conditions (including both temperatures and humidity levels) under which specimens are pre-conditioned, the elevated temperature exposure environment, the re-conditioning environment after heating, as well as the conditions under which the planar dimensional measurements are taken. Specimens tested in various environments can exhibit differences in dimensional stability.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer having a flat anvil interface, or a caliper of suitable size, shall be used. The accuracy of the instrument(s) shall be suitable for reading to within 0.5 % of the sample length, width and thickness. For typical specimen geometries, an instrument with an accuracy of ± 0.025 mm [± 0.001 in.] is desirable for thickness measurement, whereas an instrument with an accuracy of ± 0.25 mm [± 0.01 in.] is desirable for length and width measurement.

7.2 *Balance or Weighing Scale*—An analytical balance or weighing scale is required that is capable of measuring the mass of the core material accurately to ± 0.5 %.

7.3 *Oven*—An air-circulating oven is required that shall be capable of maintaining the required temperature to within ± 3 °C [± 5 °F].

8. Sampling and Test Specimens

8.1 *Sampling*—Test at least five specimens per test condition unless valid results can be gained through the use of fewer specimens, such as in the case of a designed experiment. For statistically significant data, consult the procedures outlined in Practice E122. Report the method of sampling.

8.2 Test Specimens:

8.2.1 *Core Thickness*—Standard test specimens shall utilize 13 mm [0.50 in.] thick core. When assessing dimensional stability characteristics of core used in specific sandwich constructions, it is recommended to test the actual core thickness used in the end application. Tests conducted using non-standard core thicknesses must be designated as such, with the core thickness reported with any test results.

8.2.2 *Core Planar Geometry*—Core test specimens shall be approximately 450 mm [18 in.] by 900 mm [36 in.] in the planar dimensions. For honeycomb cores, the planar dimension cross section is defined to be in the facing plane (in regard to the orientation that the core would be placed in a structural sandwich construction) and is perpendicular to the orientation of the cell walls. For honeycomb cores the 450-mm [18-in.] dimension is the core's ribbon or *L* direction. Other dimensions can be used, but must be reported. Smaller specimens may be used if oven size is limited.

8.2.3 *Core Preparation and Machining*—Prepare the core material samples so that the facing plane surfaces are parallel to each other and perpendicular to the sides of the core. Take precautions when cutting specimens from large sheets of core material to avoid notches, undercuts, rough or uneven surfaces due to inappropriate machining methods. Record and report the core material specimen cutting preparation method.

8.3 *Labeling*—Label the test specimens so that they will be distinct from each other and traceable back to the sheet of origin, and will neither influence the test nor be affected by it.

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of use of the equipment.

10. Conditioning

10.1 Pre-test environmental conditioning requirements shall be specified by the test requestor. The recommended pre-test condition is effective moisture equilibrium at a specific relative humidity as established by Test Method D5229/D5229M; however, if the test requestor does not explicitly specify a pre-test conditioning environment, no conditioning is required and the test specimens may be tested as prepared.

10.2 The pre-test specimen conditioning process, to include specified environmental exposure levels and resulting moisture content, shall be reported with the test data.

NOTE 1—The term “moisture,” as used in Test Method D5229/D5229M includes not only the vapor of a liquid and its condensate, but the liquid

itself in large quantities, as for immersion.

10.3 If no explicit pre-test conditioning process is performed, the pre-test specimen conditioning process shall be reported as “unconditioned” and the moisture content as “unknown.”

10.4 Post-heating environmental conditioning requirements shall be specified by the test requestor. The recommended post-heating condition is moisture content equivalency to that after pre-test conditioning, which is obtained by re-conditioning the specimen in the same conditioning environment used for pre-conditioning for an equivalent duration. If the test requestor does not explicitly specify a re-conditioning environment, no re-conditioning is required.

10.5 The specimen re-conditioning process, to include specified environmental exposure levels, shall be reported with the test data.

10.6 If no explicit re-conditioning process is performed, the specimen re-conditioning process shall be reported as “unconditioned” and the moisture content as “unknown.”

11. Procedure

11.1 *Parameters to be Specified Before Test:*

11.1.1 The specimen sampling method, specimen geometry, and conditioning travelers (if required).

11.1.2 The properties and data reporting format desired.

NOTE 2—Determine specific material property, accuracy, and data reporting requirements prior to test for proper selection of apparatus.

11.1.3 The environmental pre-conditioning and re-conditioning parameters.

11.2 *General Instructions:*

11.2.1 Report any deviations from this test method, whether intentional or inadvertent.

11.2.2 If core material density is to be reported, then obtain these samples from the same sheet of core material being tested. Density may be evaluated in accordance with Test Method **C271/C271M**.

11.2.3 Following final core material specimen machining, but before conditioning and testing, measure the specimen length and width in the planar dimensions at three places. The thickness of the specimen shall be measured at four locations and recorded as the average of the four measurements. The accuracy of these measurements shall be within 0.5 % of the dimension. Measure the specimen length and width with an accuracy of ± 0.25 mm [± 0.010 in.]. Measure the specimen thickness with an accuracy of ± 0.025 mm [± 0.001 in.]. Record the dimensions to three significant figures in units of millimeters [inches]. If the specimen warps, it may be flattened while making the measurements.

11.2.4 Determine the mass of the specimen with an accuracy of ± 0.5 %.

11.3 Condition the specimens as required. Store the specimens in the conditioned environment until test time, if the test environment is different than the conditioning environment. Record the total time that the specimens are exposed to the conditioning environment.

11.4 Following final specimen conditioning, but before testing, re-measure the specimen length, width, and thickness as in **11.2.3**, and re-measure the specimen mass as in **11.2.4**.

11.5 Mark the specimen in eight locations as shown in **Fig. 1**. For honeycomb core, it is recommended that the cells be potted with a resin at the eight locations and then marked (see **Fig. 2**). Recommended dimensional locations for the eight markings are shown in **Fig. 3**.

11.6 Measure the dimensions between the marked locations with an accuracy of ± 0.25 mm [± 0.010 in.]. Make three measurements in one direction and three measurements in the other direction, as shown in **Fig. 3**.

11.7 Preheat the oven to 175 ± 3 °C [350 ± 5 °F] and place the specimen flat on a wire-mesh-type shelf. Other temperatures may be used but must be reported.

11.8 After 90 min exposure in the oven, remove the specimen from the oven and allow to cool in the specified re-conditioning environment.

11.9 When the specimen is at room temperature, re-measure the six dimensions as in **11.6** and record as the immediate post-heating dimensions. The immediate post-heating dimensional changes reflect the combined effects of heating and drying upon the core dimensional stability.

11.10 Re-condition the specimen in the same conditioning environment used to pre-condition the specimen, for at least the same total time recorded in **11.3**.

11.11 Re-measure the six dimensions as in **11.6**, and record as the final post-heating dimensions. The final post-heating dimensional changes reflect the effects of heating upon the core, as the final moisture content should approximate the pre-conditioned moisture content.

12. Validation

12.1 Property values shall not be calculated for any specimen that contains some obvious flaw described in **6.1**, unless such flaw constitutes a variable being studied. Retests shall be performed for any specimen on which values are not calculated.

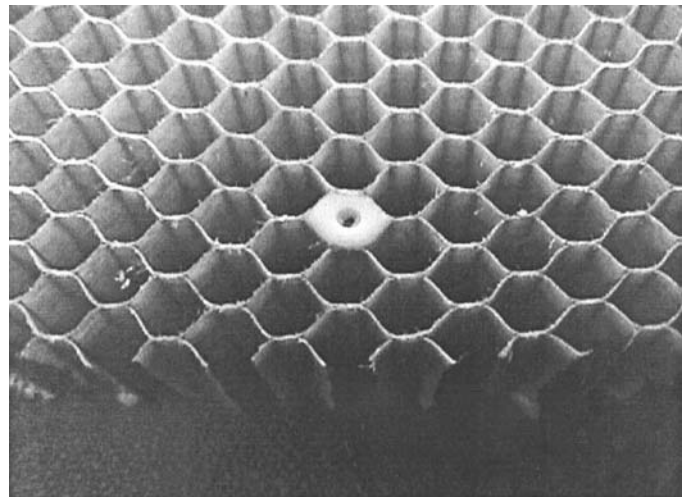
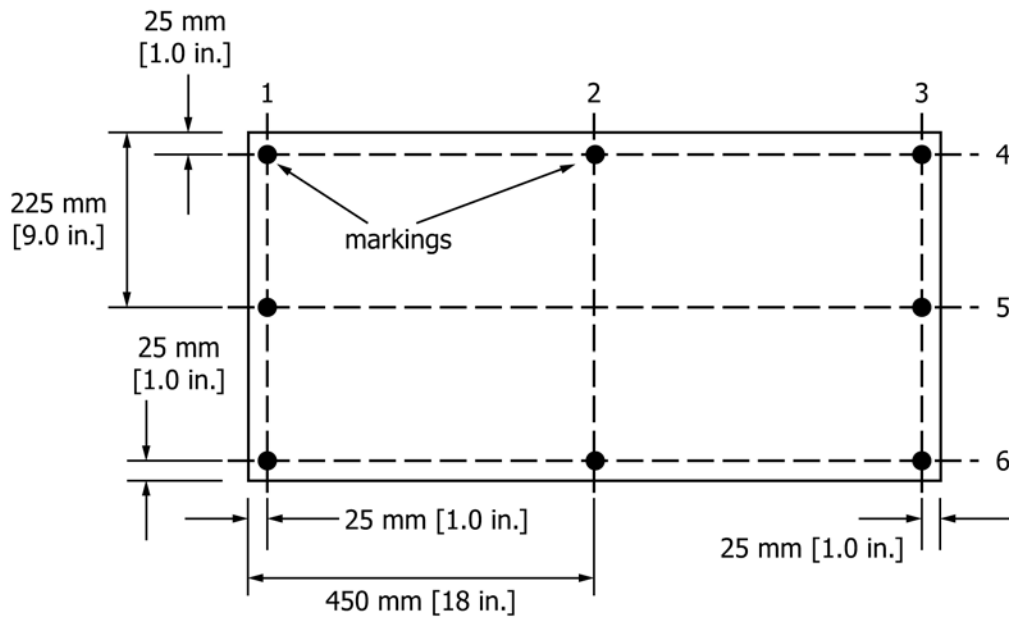


FIG. 2 Potted Honeycomb Cell



Dimensional tolerances are linear ± 13 mm [± 0.5 in.].

FIG. 3 Measurement Locations

13. Calculations

13.1 *Dimensional Changes*—Calculate the dimensional changes as follows, for both the initial post-heating measurements and the final post-heating measurements:

$$\text{percent change} = \frac{(L_f - L_i)}{L_i} \times 100 (\%) \quad (1)$$

where:

L_i = initial (pre-test) measured dimension, and
 L_f = post-heating measured dimension.

13.2 *Statistics*—For each series of tests, calculate average value, standard deviation and coefficient of variation (in percent) for the average specimen dimensional change in each of the two directions (both initial and final post-heating):

$$\bar{x} = \left(\frac{\sum_{i=1}^n x_i^2 - n \bar{x}^2}{n} \right) / n \quad (2)$$

$$S_{n-1} = \sqrt{\left(\frac{\sum_{i=1}^n x_i^2 - n \bar{x}^2}{n - 1} \right)} \quad (3)$$

$$CV = 100 \times S_{n-1} / \bar{x} \quad (4)$$

where:

\bar{x} = sample mean (average) specimen dimensional change in each direction;
 S_{n-1} = sample standard deviation in each direction;
 CV = sample coefficient of variation, %;
 n = number of specimens; and
 x_i = measured or derived property.

14. Report

14.1 Report the following information, or references pointing to other documentation containing this information, to the maximum extent applicable (reporting of items beyond the control of a given testing laboratory, such as might occur with

material details or specimen fabrication parameters, shall be the responsibility of the requestor):

- 14.1.1 The revision level or date of issue of this test method,
- 14.1.2 The name(s) of the test operator(s),
- 14.1.3 Any variations to this test method, anomalies noticed during testing, or equipment problems occurring during testing,
- 14.1.4 Identification of all the materials constituent to the sandwich core specimen tested, including for each: material specification, material type, manufacturer's material designation, manufacturer's batch or lot number, source (if not from manufacturer), date of certification, and expiration of certification,
- 14.1.5 Description of the fabrication steps used to prepare the sandwich core specimen, including: fabrication start date, fabrication end date, process specification(s), and a description of the equipment used,
- 14.1.6 Method of preparing the test specimen, including specimen labeling scheme and method, specimen geometry, sampling method, specimen cutting method(s) and specimen potting method,
- 14.1.7 Results of any nondestructive evaluation tests,
- 14.1.8 Calibration dates and methods for all measurements and test equipment,
- 14.1.9 Type of balance or weighing scale and measurement accuracy,
- 14.1.10 Individual values of length, width, and thickness for each specimen (prior to and after conditioning, if appropriate),
- 14.1.11 Mass of specimen prior to and after conditioning, if appropriate,
- 14.1.12 Measured core density,
- 14.1.13 Pre-conditioning parameters and results, including total time in conditioning,
- 14.1.14 Relative humidity and temperature of the testing laboratory,



14.1.15 Number of specimens tested,

14.1.16 Oven temperature and length of time specimens are in oven,

14.1.17 Individual initial post-heating dimensional changes, average dimensional changes, and maximum dimensional changes in percent for the two directions for each specimen,

14.1.18 Re-conditioning parameters and results, including total time in conditioning,

14.1.19 Individual final post-heating dimensional changes, average dimensional changes, and maximum dimensional changes in percent for the two directions for each specimen, and

14.1.20 Average dimensional changes in percent, standard deviation and coefficient of variation for the two directions for all specimens, for both initial and final post-heating measurements.

15. Precision and Bias

15.1 *Precision*—The data required for the development of a precision statement are not available for this test method.

15.2 *Bias*—Bias cannot be determined for this test method as no acceptable reference material exists.

16. Keywords

16.1 core; dimensional stability; honeycomb

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