Designation: C 271/C 271M – 05

Standard Test Method for Density of Sandwich Core Materials[1]

This standard is issued under the fixed designation C 271/C 271M; 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 density of sandwich construction core materials. Permissible core material forms include those with continuous bonding surfaces (such as balsa wood and foams) as well as those with discontinuous bonding surfaces (such as honeycomb).

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

C 274 Terminology of Structural Sandwich Constructions
D 883 Terminology Relating to Plastics
D 3878 Terminology for Composite Materials
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
E 122 Practice for Calculation of Sample Size to Estimate, With a Tolerable Specified Error, the Average for Characteristic of a Lot or Process
E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E 456 Terminology Relating to Quality and Statistics
E 1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases
E 1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases

3. Terminology

3.1 *Definitions*—Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology C 274 defines terms relating to structural sandwich constructions. Terminology D 883 defines terms relating to plastics. Terminology E 456 and Practice E 177 define terms relating to statistics. In the event of a conflict between terms, Terminology D 3878 shall have precedence over the other terminologies.

3.2 *Symbols*:

CV = coefficient of variation statistic of a sample population for a given property (in percent)
d_{IP} = density of a test specimen in inch-pound units
d_{SI} = density of a test specimen in SI units
l = length of a test specimen
S_{n-1} = standard deviation statistic of a sample population for a given property
t = thickness of a test specimen
x_i = test result for an individual specimen from the sample population for a given property
$\bar{x}$ = mean or average (estimate of mean) of a sample population for a given property
w = width of a test specimen
W = mass of a test specimen

4. Summary of Test Method

4.1 This test method consists of environmentally conditioning a sandwich core specimen, weighing the specimen, measuring the length, width and thickness of the specimen, and calculating the density.

[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.

Current edition approved April 1, 2005. Published April 2005. Originally approved in 1951. Last previous edition approved in 1999 as C 271 – 99.

[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.

5. Significance and Use

5.1 Density is a fundamental physical property that can be used in conjunction with other properties to characterize the sandwich core. Most sandwich core structural properties, such as strength and stiffness, are proportional to the density.

5.2 This test method provides a standard method of obtaining sandwich core density data for design properties, material specifications, research and development applications, and quality assurance.

5.3 Factors that influence the density and shall therefore be reported include the following: core material, methods of material fabrication, core geometry (nominal cell size), specimen geometry, specimen preparation, methods of weight and dimensional measurement, specimen conditioning, and moisture content during weight and dimensional measurements.

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 in composites and sandwich structures in general. 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 *Geometry*—Specific geometric factors that affect sandwich density measurement include uniformity of core cell geometry and core thickness.

6.3 *Environment*—Results are affected by the environmental conditions under which specimens are conditioned, as well as the conditions under which the tests are conducted. Specimens tested in various environments, with different ambient moisture contents, can exhibit significant differences in measured density.

7. Apparatus

7.1 *Oven or Vacuum Drying Chamber*—An air-circulating oven is required that shall be capable of maintaining the required uniform temperatures to within ±3°C [±5°F]. A vacuum drying chamber or a vacuum oven may also be used.

7.2 *Desiccator*—A clean, dry desiccator in which specimens being oven-dried shall be brought to laboratory temperature following removal of the specimens from the oven.

7.3 *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 specimen length, width and thickness. For typical specimen geometries, an instrument with an accuracy of ±25 µm [±0.001 in.] is desirable for length, width, and thickness measurement.

7.4 *Balance or Weighing Scale*—An analytical balance or weighing scale is required that is capable of measuring accurately to ±0.5 %.

7.5 *Gloves*—Clean, non-linting gloves for use when handling specimens.

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, as in the case of a designed experiment. For statistically significant data, consult the procedures outlined in Practice E 122. Report the method of sampling.

8.2 *Geometry*—Test specimens shall have a square or rectangular cross-section. The recommended minimum specimen size is 300 mm [12.0 in.] in length by 300 mm [12.0 in.] in width, with the thickness equal to the sandwich core thickness.

NOTE 1—The specimen's cross-sectional area (length times width) is defined in the facing plane, in regard to the orientation that the core would be placed in a structural sandwich construction. For example, for a honeycomb core the cross-sectional area is defined in the plane of the cells, which is perpendicular to the orientation of the cell walls.

8.3 *Specimen Preparation and Machining*—Prepare the test specimens so that the facing plane surfaces are parallel to each other and perpendicular to the sides of the specimen. Take precautions when cutting specimens from large sheets of core to avoid notches, undercuts, rough or uneven surfaces due to inappropriate machining methods. Obtain final dimensions by lubricated precision sawing, milling, or grinding. The use of diamond tooling has been found to be extremely effective for many material systems. Record and report the specimen cutting preparation method.

8.4 *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 Subject the test specimens to one of the following conditions:

10.1.1 Standard ASTM Atmospheric Conditions (Specification E 171) of 23 ± 3°C [73 ± 5°F] and 50 ± 5 % relative humidity, in accordance with Procedure C of Test Method D 5229/D 5229M.

10.1.2 In oven-dried equilibrium at a temperature of 105 ± 3°C [220 ± 5°F], in accordance with Procedure D of Test Method D 5229/D 5229M.

10.1.3 In oven-dried equilibrium at a temperature of 40 ± 3°C [120 ± 5°F], in accordance with Procedure D of Test Method D 5229/D 5229M.

10.2 After conditioning, cool the specimens at room temperature. Store and test the specimens in accordance with the appropriate procedure of Test Method D 5229/D 5229M.

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 conditioning test parameters.

11.1.4 The balance or weighing scale measurement accuracy.

11.2 *General Instructions*:

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

11.2.2 Following final specimen machining, but before conditioning and testing, measure the specimen length, width and thickness. The accuracy of these measurements shall be within 0.5 % of the dimension. Measure the specimen length, width and thickness with an accuracy of ±25 μm [±0.001 in.]. Record the dimensions to three significant figures in units of millimetres [inches].

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.

11.4 Following final specimen conditioning, but before testing, re-measure the specimen length, width, and thickness as in 11.2.2.

11.5 *Weigh Specimen*—Weigh the specimens in grams [lbm] to a precision of ±0.5 %.

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.

13. Calculation

13.1 *Density*—Calculate the density to three significant figures. Utilize Eq 1 when using SI units and Eq 2 when using inch-pound units.

$$d_{SI} = \frac{1\,000\,000\,W}{lwt} \tag{1}$$

where:

d_{SI} = density, kg/m^3,
W = final mass after conditioning, g,
l = final length after conditioning, mm,
w = final width after conditioning, mm, and
t = final thickness after conditioning, mm.

$$d_{IP} = \frac{1728\,W}{lwt} \tag{2}$$

where:

d_{IP} = density, lbm/ft^3,
W = final mass after conditioning, lbm,
l = final length after conditioning, in.,
w = final width after conditioning, in., and
t = final thickness after conditioning, in.

NOTE 3—Reporting of core density in units of kg/m^3 or lbm/ft^3 is an industry standard.

NOTE 4—The pound mass is defined such that one pound force imparts an acceleration of 32.17 feet per second to it. In standard gravity, one pound force is numerically the same as one pound mass.

13.2 *Density Conversion*—Conversion of density values to inch-pound units from SI units is accomplished using Eq 3. Conversion of density values to SI units from inch-pound units is accomplished using Eq 4.

$$d_{IP} = 0.0624\,d_{SI} \tag{3}$$

$$d_{SI} = 16\,d_{IP} \tag{4}$$

13.3 *Statistics*—For each series of tests calculate the average value, standard deviation, and coefficient of variation (in percent) for density:

$$\bar{x} = \left(\sum_{i=1}^{n} x_i\right) / n \tag{5}$$

$$S_{n-1} = \sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\,\bar{x}^2\right) / (n-1)} \tag{6}$$

$$CV = 100 \times S_{n-1} / \bar{x} \tag{7}$$

where:

$\bar{x}$ = sample mean (average),
S_{n-1} = sample standard deviation,
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 panel fabrication parameters, shall be the responsibility of the requestor):

NOTE 5—Guides E 1309, E 1434 and E 1471 contain data reporting recommendations for composite materials and composite materials testing.

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 including: fabrication start date, fabrication end date, process specification, 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, and specimen cutting 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 Measured length, width, and thickness for each specimen (prior to and after conditioning, if appropriate).

14.1.11 Mass of specimen.

14.1.12 Conditioning parameters and results.

14.1.13 Relative humidity and temperature of the testing laboratory.

14.1.14 Number of specimens tested.

14.1.15 Individual densities and average value, standard deviation, and coefficient of variation (in percent) for the population.

15. Precision and Bias

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

15.2 *Bias*—Bias cannot be determined for this method as no acceptable reference standards exist.

16. Keywords

16.1 core; density; sandwich