Designation: C272/C272M – 16

Standard Test Method for Water Absorption of Core Materials for Sandwich Constructions[1]

This standard is issued under the fixed designation C272/C272M; 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 test method covers the determination of the relative amount of water absorption by various types of sandwich construction core materials when immersed in water, or when subjected to a high relative humidity environment. 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. 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]

D883 Terminology Relating to Plastics
D1193 Specification for Reagent Water
D3878 Terminology for 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

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 *D*—pre-immersion mass of a test specimen.

3.2.3 *h*—height of a test specimen.

3.2.4 *l*—length of a test specimen.

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

3.2.6 x_1—test result for an individual specimen from the sample population for a given property.

3.2.7 *x*—mean or average (estimate of mean) of a sample population for a given property.

3.2.8 *V*—volume of a test specimen.

3.2.9 *w*—width of a test specimen.

3.2.10 *W*—mass of a test specimen.

4. Summary of Test Method

4.1 This test method consists of exposing sandwich core specimen to a defined moisture condition, and determining the amount of water absorbed by measuring the mass increase in the specimen.

5. Significance and Use

5.1 Absorbed water affects the characteristic properties of sandwich core materials, such as electrical properties (for example, dielectric constant, loss tangent, and electrical resistance) and mechanical properties (for example, strength and

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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.

modulus). The mass of absorbed water may also affect the behavior of sandwich structures. It should be noted that in a sandwich panel the presence of facings bonded on two sides of the core may affect the amount of water absorbed by the core.

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

5.3 Factors that influence the water absorption and shall therefore be reported include the following: core material, methods of material fabrication, core geometry (honeycomb cell size, honeycomb cell wall thickness, foam pore size, etc.), specimen geometry, specimen preparation, methods of mass and dimensional measurement, specimen conditioning, and moisture content during mass 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. Cracks in the specimen and rough surfaces can increase the apparent water absorption.

6.2 *Surface Water*—Some core materials tend to collect water on the surfaces or trap water in corners, and, if not removed will give incorrect results.

6.3 *Environment*—Results are affected by the environmental conditions under which specimens are conditioned.

7. Apparatus

7.1 *Analytical Balance or Weighing Scale*—An analytical balance or weighing scale is required that is capable of measuring accurately to 0.001 g.

7.2 *Oven:*

7.2.1 *Circulating Air Oven*—For Procedure A and C tests, an air-circulating oven is required that shall be capable of maintaining the required uniform temperatures to within ±3°C [±5°F].

7.2.2 *Circulating Air Vacuum Oven*—For Procedure B tests, an air-circulating oven is required that shall be capable of maintaining the required uniform temperatures to within ±3°C [±5°F], shall be capable of achieving full vacuum, and shall have a drying device on the air inlet line.

7.3 *Desiccator*—A clean, dry desiccator is required; specimens being oven-dried shall be brought to laboratory temperature following removal from the oven.

7.4 *Humidity Chamber*—A humidity chamber is required that shall be capable of maintaining uniform relative humidity with an accuracy of ±5 % and a uniform temperature with an accuracy of ±3°C [±5°F].

7.5 The water used in this test method shall be distilled water (Specification D1193, Type IV reagent water) or deionized water.

8. Sampling and Test Specimens

8.1 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 *Geometry*—Test specimens shall have a square or rectangular cross-section. The recommended specimen size is 75 mm [3.0 in.] in length by 75 mm [3.0 in.] in width by 13 mm [0.5 in.] in 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*—Machine, saw, or shear the test specimens from the core sample so as to have smooth surfaces that are free from cracks and facing plane surfaces that are parallel to each other and perpendicular to the sides of the specimen. 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. Pre-Test Conditioning

10.1 Oven dry the specimens as follows:

10.1.1 For materials whose water absorption value would be affected by temperatures up to approximately 110°C [230°F], dry the specimens in an oven for 24 h at 50 ± 3°C [120 ± 5°F], cool in a desiccator to room temperature, remove, and immediately weigh and record the mass. After weighing, immediately place the specimens in the water or humidity chamber.

10.1.2 For materials whose water absorption value has been shown not to be affected by temperatures up to 110°C [230°F], dry the specimens in an oven for 2 h at 105 ± 3°C [225 ± 5°F], cool in a desiccator to room temperature, remove, and immediately weigh and record the mass. After weighing, immediately place the specimens in the water or humidity chamber.

10.1.3 For specimens to be conditioned using Procedure B below, dry the specimens per 10.1.1 or 10.1.2 in a vacuum drying oven without application of vacuum. After the time periods specified above, apply full vacuum for 30 min to remove remaining traces of moisture. When reducing the vacuum level, ambient venting air should be passed through a calcium sulfate desiccant or suitable alternate in-line trap.

10.2 In the case of a new material of which the water absorption properties are not known, conditioning separate specimens in accordance with 10.1.1 and 10.1.2, followed by the specified procedure below is recommended until sufficient experience on the effect of temperature is achieved to indicate the selection of the most satisfactory method.

11. Procedure

11.1 *Parameters to Be Specified Before Test:*

11.1.1 The specimen sampling method and specimen geometry.

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 pre-test conditioning method and parameters.

11.1.4 The balance or weighing scale measurement accuracy.

11.1.5 The conditioning procedure (A, B or C) to be used.

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 ±0.025 mm [±0.001 in.]. Record the dimensions to three significant figures in units of millimetres [inches].

11.3 Condition the specimens using one of the following conditioning environments, as specified by the test requestor:

11.3.1 *Procedure A Twenty-Four-Hour Immersion*—Immerse the specimens in a container horizontally under 25 mm [1.0 in.] minimum head of water for 24 + 1, – 0 h, maintained at a temperature of 23 ± 3°C [73 ± 5°F]. Core materials that float should be held under water by a loose net or other means which will not greatly affect the exposed surface area of the specimen.

11.3.1.1 Remove the specimens from conditioning, shake vigorously and wipe off all surface water with a dry cloth until no visible water is present. For materials that tend to collect water on the surfaces or trap water in corners, dip the specimen in isopropyl alcohol, shake vigorously, allow the alcohol to evaporate, and immediately weigh and record the mass.

11.3.1.2 Re-measure the specimen length, width and thickness as in 11.2.2.

11.3.1.3 Weigh and record the mass of each specimen in grams to a precision of ±0.001 g.

11.3.2 *Procedure B Elevated Temperature Humidity*—The standard conditioning environment shall be 70 ± 3°C [160 ± 5°F] and 85 ± 5 % relative humidity for 30 days. Other temperatures, relative humidities, and lengths of time can be used if specified by the test requestor but must be reported. The specimens shall be placed in the conditioning chamber with the 75 by 75 mm [3.0 by 3.0 in.] planes in the vertical position and the ends sitting on an open base (such as a screen or perforated material). After conditioning, allow the specimens to cool to room temperature.

11.3.2.1 Remove the specimens from conditioning, shake vigorously and wipe off all surface water with a dry cloth until no visible water is present. For materials that tend to collect water on the surfaces or trap water in corners, dip the specimen in isopropyl alcohol, shake vigorously, allow the alcohol to evaporate, and immediately weigh and record the mass.

11.3.2.2 Re-measure the specimen length, width and thickness as in 11.2.2.

11.3.2.3 Weigh and record the mass of each specimen in grams to a precision of ±0.001 g.

11.3.3 *Procedure C Maximum Percent Mass Gain*—Immerse the specimens in a container as in Procedure A for 48 + 1, – 0 h.

11.3.3.1 Remove the specimens from conditioning, shake vigorously and wipe off all surface water with a dry cloth until no visible water is present. For materials that tend to collect water on the surfaces or trap water in corners, dip the specimen in isopropyl alcohol, shake vigorously, allow the alcohol to evaporate, and immediately weigh and record the mass.

11.3.3.2 Re-measure the specimen length, width and thickness as in 11.2.2.

11.3.3.3 Weigh and record the mass of each specimen in grams to a precision of ±0.001 g.

11.3.3.4 Place the specimens back into the water and repeat this process until the mass gain after the last 48-h interval is less than 2 % of the entire mass gain of all the previous intervals.

11.4 *Surface Water Correction*—A typical indication that surface water is present on the specimen is a significantly or randomly, or both, varying moisture content versus time. When surface water on the specimens presents such problems, determine the amount of surface water left on the specimens using the following procedure:

11.4.1 Prepare five control samples identical to the test specimens.

11.4.2 Perform the same pre-test conditioning per 10.1 as used for the test specimens.

11.4.3 Weigh and record the mass of each of the control samples in grams to a precision of ±0.001 g.

11.4.4 Dip each control sample quickly in water, shake vigorously and wipe off all surface water with a dry cloth until no visible water is present. For materials that tend to collect water on the surfaces or trap water in corners, dip the specimen in isopropyl alcohol, shake vigorously, allow the alcohol to evaporate, and immediately weigh and record the mass.

11.4.5 Subtract the post-dip mass from the initial mass to obtain the surface water mass gain for each specimen.

11.4.6 Repeat steps 11.4.2 – 11.4.5 two more times for each of the five control samples.

11.4.7 Calculate the average surface water mass gain from the results of the 15 control sample tests.

11.4.8 Subtract the average surface water mass gain from each individual Procedure A - C test specimen result to estimate the actual wet specimen mass gain.

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 Calculate the percentage increase in mass as follows:

$$\text{Increase in mass, } \% = \frac{W - D}{D} \times 100 \quad (1)$$

where:

W = specimen mass after immersion and blotting, g
D = pre-immersion mass of the specimen, g

13.2 For continuous type cores (not honeycomb cell core materials), calculate the water absorption per unit volume as follows:

$$\text{water absorption per unit volume} = \frac{W - D}{V}\ g/cm^3 \quad (2)$$

where:

h = specimen height, cm [in.]
l = specimen length, cm [in.]
w = specimen width, cm [in.]
V = specimen volume = l × w × h, cm^3 [$in.^3$]
D = pre-immersion mass of the specimen, g
W = specimen mass after immersion and blotting, g

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

$$\bar{x} = \left(\sum_{i=1}^{n} X_i \right) / n \quad (3)$$

$$S_{n-1} = \sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\,\bar{x}^2 \right) / (n-1)} \quad (4)$$

$$CV = 100 \times S_{n-1} / \bar{x} \quad (5)$$

where:

$\bar{x}$ = sample mean (average)
S_{n-1} = sample standard deviation
CV = sample coefficient of variation, %
n = number of specimens
x_1 = 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).

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 prior to and after conditioning.

14.1.12 Conditioning parameters.

14.1.13 Number of specimens tested.

14.1.14 Individual specimen water absorption percentage by mass or volume (note if corrected for surface water), or both, 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 test method as no accepted reference standard exists.

16. Keywords

16.1 moisture content; water absorption; water saturation