Designation: C209 – 15

# Standard Test Methods for Cellulosic Fiber Insulating Board[1]

This standard is issued under the fixed designation C209; 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 These test methods cover those insulation products in specified Specification C208. The requirements for the products' physical properties are specified in Specification C208. The methods for the general insulation products' physical properties are given as follows:

| | Section |
|---|---|
| Thickness | 7 |
| Size of Finished Board | 8 |
| Thermal Conductivity | 9 |
| Transverse Strength | 10 |
| Deflection at Specified Minimum Load | 11 |
| Tensile Strength Parallel to Surface | 12 |
| Tensile Strength Perpendicular to Surface | 13 |
| Water Absorption | 14 |
| Linear Expansion | 15 |
| Water Vapor Transmission | 16 |
| Flame Spread Index | 17 |
| Moisture Content and Density | 18 |
| Compressive Strength | 19 |

1.2 Reference is provided to an established source for nomenclature and definitions.

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.*

1.4 Several of the test methods contained in this document are referenced by material specifications other than cellulosic fiber insulating board. These include mineral fiber, perlite, polyisocyanurate, polystyrene and phenolic materials.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C165 Test Method for Measuring Compressive Properties of Thermal Insulations

C168 Terminology Relating to Thermal Insulation

C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

C208 Specification for Cellulosic Fiber Insulating Board

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

C870 Practice for Conditioning of Thermal Insulating Materials

C1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions

C1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus

D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

D1554 Terminology Relating to Wood-Base Fiber and Particle Panel Materials

E84 Test Method for Surface Burning Characteristics of Building Materials

E96/E96M Test Methods for Water Vapor Transmission of Materials

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

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

## 3. Terminology

3.1 *Definitions*—The definitions of terms used in these methods shall be in accordance with Definitions D1554 and Terminology C168.

3.2 *cellulosic fiber insulating board*—a fibrous-felted, homogeneous panel made from ligno-cellulosic fibers (usually wood ) and having a density of less than 31 lb/ft$^3$ (497 kg/m$^3$) but more than 10 lb/ft$^3$ (160 kg/m$^3$).

3.2.1 *Discussion*—Cellulosic fiber insulating board. It is characterized by an integral bond that is produced by interfelting of the fibers, but which has not been consolidated under heat and pressure as a separate stage in manufacture. Other materials may be added during manufacture to improve certain properties.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *board*—refers to the material as received.

[1] These test methods are under the jurisdiction of ASTM Committee C16 on Thermal Insulation and are the direct responsibility of Subcommittee C16.32 on Mechanical Properties.

Current edition approved Oct. 1, 2015. Published October 2015. Originally approved in 1946. Last previous edition approved in 2012 as C209 – 12. DOI: 10.1520/C0209-15.

[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.

3.3.2 *sample*—refers to the 36 by 48-in. (0.9 by 1.2-m) piece cut from a board.

3.3.3 *test specimen*—refers to the test piece cut from a sample unless otherwise specified in the test method.

3.3.4 *sorption*—a general term in physical chemistry used to describe the combined processes of:

*(1) absorption*—refers to the taking up of matter in bulk by other matter, for example, the penetration of substances into the bulk of another solid or liquid.

*(2) adsorption*—refers to surface retention or adhesion of an extremely thin layer of molecules to the surfaces of solids or liquids with which they are in contact.

## 4. Significance and Use

4.1 The test methods contained in this document are intended for cellulosic fiber insulating board as described in Specification C208. These test methods examine mechanical, physical and thermal properties, properties related to water absorption and water vapor exposure, and flammability related properties.

4.2 The results of these tests are suitable to describe the performance of insulating board and are also suitable for use in material specifications.

NOTE 1—Committee C-16 is in the process of splitting this document into discrete test methods categorized by the nature of the test methods.

## 5. Sampling

5.1 *Selection of Boards*—Refer to Specification C208, Section 9 on Sampling.

5.2 *Size of Sample*—From each board a sample, 36 by 48 in. (0.9 by 1.2 m) shall be cut. When possible, the larger dimension of the sample shall be crosswise of the longer dimension of the board as it is usually obtained. When the individual boards are less than 36 by 48 in. (0.9 by 1.2 m) in size, enough material shall be taken to give the equivalent area.

## 6. Test Conditions

6.1 *Preconditioning*—Tests shall be made under prevailing atmospheric conditions except in the case of dispute. Tests then shall be made on specimens conditioned until equilibrium is obtained in accordance with Practice C870.

## 7. Thickness

7.1 *Apparatus*—An instrument such as a dial gage capable of measuring a 36 by 48 in. (0.9 by 12 m) sample, on which the contacting surfaces are flat and have a minimum diameter of ½ in. (13 mm) shall be used. Pressure on the contacting surfaces shall not be greater than 1 psi (6.9 kPa) nor less than 0.25 psi (1.7 kPa), and the instrument shall read to an accuracy of 0.001 in. (0.03 mm).

7.2 *Procedure*—Measure the thickness at five points, near each corner and near the center, to an accuracy of ±0.001 in. (±0.02 mm). Take care that the sample is not deformed when the thickness measurements are taken.

7.3 *Calculation and Report*—Report the average of the five measurements as the average thickness of the sample. Report as the average thickness of the sample, the average thickness of the lot, report thickness tolerance, as follows:

$$\text{Thickness tolerance} = (h_1 - h_2)/h_1 \quad (1)$$

where:

$h_1$ = average thickness of lot, and
$h_2$ = average thickness of sample.

## 8. Size of Finished Board

8.1 *Procedure*—Obtain the average width of the finished board by measuring the width at each end and at the middle to an accuracy of ±0.3 % or ⅛ in. (2 mm), whichever is smaller, and averaging these readings. Obtain the average length of the finished board in a similar manner.

## 9. Thermal Conductivity

9.1 *Procedure*—Determine thermal conductivity in accordance with Test Method C177, or in accordance with Test Methods C518, C1045 or C1114. Test two specimens from one sample from one board.

## 10. Transverse Strength

10.1 *Apparatus:*

10.1.1 *Testing Machine*—Any standard mechanical or hydraulic testing machine capable of applying and measuring the required load within an accuracy of ±2 % is suitable for use.

10.1.2 *Bearing Edges*—The bearing edges shall be rounded to a radius of ⅜ in. (10 mm) to prevent injury to the specimen. The bearing edges shall be straight and shall maintain full contact with the specimen throughout the test.

10.2 *Test Specimen*—The specimen shall be 3 by 15 in. (76 by 381 mm) and conditioned in accordance with 6.1. Three specimens from the long dimension of each sample from each board and three at right angles shall be tested. If the sample has a dimension less than 15 in. (381 mm), test only in that direction for which a 15 in. (381 mm) specimen can be obtained.

10.3 *Procedure*—Determine the transverse load by placing the specimen on horizontal bearing edges 12 in. (305 mm) apart and applying the load at midspan on a bearing parallel to the end supports, so that the head of the testing machines, through which the load is applied, moves at a rate of 6 ± 2 in./min (152 ± 51 mm/min) until failure occurs.

10.4 *Calculation and Report*—Report as the transverse load for specimen, the maximum load reached during the test. Report as the average transverse load in pounds-force (or Newtons) in each direction for a sample, the average of three specimens taken from that direction. Report as the total average transverse load in each direction, the average of all samples in that direction. Calculate modulus of rupture values in pounds-force per square inch (or megapascals) as follows:

$$MOR = 6P/t^2 \quad (2)$$

where:

$MOR$ = Modulus of rupture, psi (MPa),
$P$ = Transverse load, lbf (N), and
$t$ = thickness, in. (mm).

10.5 *Precision and Bias*—See Section 20.

## 11. Deflection at Specific Minimum Load

11.1 *Procedure*—Determine, to the nearest 0.01 in. (0.3 mm), the deflection at the corner of each specimen subjected to the minimum transverse load, by means of a suitable measuring device such as a dial gage under the specimen, a steel rule alongside the specimen, or measurement of the crosshead movement.

11.2 *Calculation and Report*—Report as the average deflection in each direction for a sample, the average of three specimens taken from that direction. Report as the total average deflection in each direction, the average of all samples in that direction.

11.3 *Precision and Bias*—See Section 20.

## 12. Tensile Strength Parallel to Surface

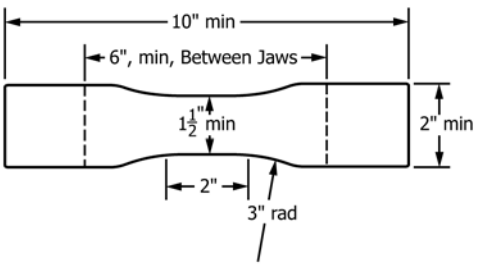
12.1 *Apparatus*—Any standard mechanical or hydraulic testing machine capable of applying and measuring the required load within an accuracy of ±2 % is suitable for use.

12.2 *Test Specimen*—Specimens shall be prepared in accordance with Fig. 1, and conditioned in accordance with 6.1. Three specimens from the long direction of each sample from each board and three at right angles thereto shall be tested.

12.3 *Procedure*—Set the testing machine for a rate of separation of the jaws of 2 ± ¼ in./min (51 ± 6 mm/min). Clamp the specimens in the jaws at a minimum distance of 6 in. (152 mm) apart. Specimens breaking within ½ in. (13 mm) of the jaws shall be disregarded. Measure the specimens, after breaking, for width and thickness at the break to the nearest 0.01 in. (0.3 mm).

12.4 *Calculation and Report*—Report as the average tensile strength in each direction for a sample, the average, in pounds-force per square inch (or kilopascals), of the three specimens taken from that direction. Report as the total average value in each direction, the average of all samples in that direction.

12.5 *Precision and Bias*—See Section 20.




**SI Equivalents**

| in. | mm | in. | mm |
|---|---|---|---|
| 10 | 254 | 2 | 51 |
| 6 | 152 | 1½ | 38 |
| 3 | 76 | | |

**FIG. 1 Specimen for Determination of Tensile Strength Parallel to Surface**

## 13. Tensile Strength Perpendicular to Surface

13.1 *Apparatus*—The apparatus shall be as shown in Fig. 2 and shall consist of two blocks 2 by 2 by 1¼ in. (51 by 51 by 32 mm) supplied with hooks in the center as shown in Fig. 2. Any standard mechanical or hydraulic testing machine capable of applying and measuring the required load within an accuracy of ±2 % is suitable for use.

13.2 *Test Specimens*—The specimen shall be cut to match the lateral dimensions of the test block in 13.1 and conditioned in accordance with 6.1. Two specimens shall be tested, one each from the sample from two boards.

13.3 *Procedure*—Cement the two surfaces of the specimens to the blocks with a suitable adhesive. After the adhesive has set a sufficient length of time, apply a load at the rate of 2 ± ¼ in./min (51 ± 6 mm/min) at the hooks until separation within the block.

13.4 *Calculation and Report*—Report the tensile strength perpendicular to the surfaces as the average of the loads in pounds-force per square foot (or kilopascals) at the time of failure of the test specimens. Note the location of the line of failure.

13.5 *Precision and Bias*—See Section 20.

## 14. Water Absorption

14.1 *Pan*—A pan or vessel not less than 15 by 15 in. (381 by 381 mm) and of the required depth.

14.1.1 *Conditioning Oven or Room*—A conditioning oven or room that can be regulated to a temperature of 73.8 ± 4°F (23 ± 2°C) and a relative humidity of 50± 5 %.

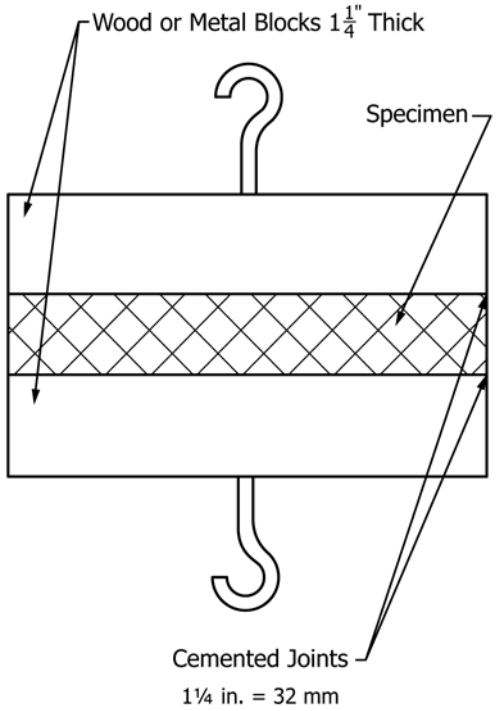



**FIG. 2 Apparatus for Determination of Tensile Strength Perpendicular to Surface**

14.1.2 *Thermometer*—An ordinary thermometer graduated in Fahrenheit or Celsuis degrees.

14.2 *Test Specimen*—The specimen shall be 12 by 12 in. (305 by 305 mm) with all four edges trimmed square. Three specimens shall be tested, one each from the sample from three boards.

14.3 *Procedure*—Condition the specimen until the practical constant weight is obtained at a temperature of 73.4 ± 4°F (23 ± 2°C) and a relative humidity of 50 ± 5 %. Measure the thickness of the specimen with reasonable accuracy and calculate the volume therefrom. Then carefully weigh the specimen and submerge it horizontally under 1 in. (25 mm) of fresh tap water, maintained at a temperature of 73.4 ± 4°F (23 ± 2°C). After 2 h of submersion, place the specimen on end to drain for 10 min; at the end of this time remove the excess surface water by hand with a blotting paper or paper towel, and immediately weigh the specimen. If a 24-h water sorption is required, conduct it in accordance with the appropriate sections of Test Methods D1037.

14.4 *Calculation and Report*—Calculate the amount of water absorbed from the increase in weight of the specimen during the submersion, and the water sorption shall be expressed as the percentage by volume based on the volume after conditioning. The specific gravity of the water shall be assumed to be 1.00 for this purpose. Report the average water absorption percent by volume of the three specimens.

14.5 *Precision and Bias*—See Section 20.

## 15. Linear Expansion

15.1 *Procedure*—Determine linear expansion due to change in moisture content in accordance with the appropriate sections of Test Methods D1037, Section 107. Test one specimen from the long dimension of each sample from each board and one at right angles thereto.

## 16. Water Vapor Transmission

16.1 *Procedure*—Determine water vapor transmission in accordance with Test Methods E96/E96M, using the desiccant method. Test three specimens, one each from the sample from three boards.

## 17. Flame Spread Index

17.1 *Procedure*—Determine flame spread index in accordance with Test Method E84.

## 18. Moisture Content and Density

18.1 *Scope*—This method covers determination of the absorption of moisture content and density at time of test, because of their relation to the strength properties. Values of density calculated from the volume and weight are satisfactory for these materials. For normal purposes, the moisture content and density of the transverse test specimens are suitable for use unless special reasons require the testing of additional samples.

18.2 *Procedure*—Weigh, measure, and dry the test specimens as presented in Test Methods D1037, Section 119.

18.3 *Calculation and Report:*

**TABLE 1 Transverse Strength (Pounds)**

| Material | Average | Repeatability Standard Deviation | Reproducibility Standard Deviation | Repeatability Limit | Reproducibility Limit |
|---|---|---|---|---|---|
| | $\bar{x}$ | sr | sR | r | R |
| A | 12.831 | 1.386 | 1.386 | 3.881 | 3.881 |
| B | 18.256 | 1.432 | 1.432 | 4.009 | 4.009 |
| C | 13.097 | 1.501 | 1.501 | 4.203 | 4.203 |
| D | 16.562 | 0.983 | 1.334 | 2.751 | 3.734 |
| E | 14.525 | 2.524 | 2.598 | 7.067 | 7.273 |

**TABLE 2 Modulus of Rupture (psi)**

| Material | Average | Repeatability Standard Deviation | Reproducibility Standard Deviation | Repeatability Limit | Reproducibility Limit |
|---|---|---|---|---|---|
| | $\bar{x}$ | sr | sR | r | R |
| A | 291.667 | 27.61 | 32.383 | 77.309 | 90.671 |
| B | 369.583 | 21.477 | 26.828 | 60.135 | 75.12 |
| C | 339.583 | 13.859 | 18.657 | 38.806 | 52.24 |
| D | 400.083 | 27.813 | 36.605 | 77.877 | 102.494 |
| E | 318.917 | 61.231 | 70.984 | 171.447 | 198.756 |

18.3.1 Calculate the moisture content as shown in Test Methods D1037, Section 120.

18.3.2 Calculate the density as follows:

$$D = 3.81F/LWT \tag{3}$$

or

$$D = (F)(1 \times 10^{6})/L'W'T'$$

where:

$D$ = density, lb/ft$^3$ (D', kg/m$^3$)
$F$ = final weight, when oven-dry, g,
$L$ = length of coupon, in. ($L$', mm),
$W$ = width of coupon, in. ($W$', mm), and
$T$ = thickness of coupon, in. ($T$', mm).

NOTE 2—The density as determined by this equation is based on volume at test and weight when oven-dry.

18.3.3 Report the moisture content and density for each individual test specimen. Do not use averages except for test specimens that have been brought to equilibrium under the same conditions.

## 19. Compressive Strength

19.1 *Procedure*—Determine compressive strength in accordance with Procedure B, Test Method C165. Measure length, width and thickness. Test three specimens using a crosshead speed of 0.05 inch (1.27 mm) per minute. Divide the load at 10% compression by the length and width. Report the average of three tests.

## 20. Precision and Bias[3]

20.1 The precision of this modulus of rupture test method is based on an interlaboratory study of C209-98, Standard Test Methods for Cellulosic Fiber Insulating Board, conducted in 2006. Each of six laboratories tested five different materials. Every "test result" represents an individual determination. All

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C16-1033.

laboratories obtained two replicate test results for each material. See Table 1 and Table 2.

20.1.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

20.1.2 *Reproducibility*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

20.1.3 Any judgment in accordance with these two statements would have an approximate 95 % probability of being correct.

20.2 *Bias*—There was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

20.3 The precision statement was determined through statistical examination of 180 results, from six laboratories, on five materials.

20.4 This precision of this water absorption test method is based on an intralaboratory study of ASTM C209 – Standard Test Methods for Cellulosic Fiber Insulating Board, conducted in 2015. Seven laboratories participated in this study, testing ASTM C208, ½ in. thick, Type II, Grade 2 Roof insulation board from four different manufacturers. Every "test result" represents an individual determination. The laboratories reported a single test result for each board. Except for the measurement of only a single test result per material, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:C16-1043.[4]

20.4.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

20.4.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

20.4.1.2 Repeatability limits cannot be determined without replicate test results.

20.4.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

20.4.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

20.4.2.2 Reproducibility limits can be found in Table 4 below.

20.4.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

20.4.4 Any judgment in accordance with 20.4.1 would normally have an approximate 95 % probability of being correct; however, the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories and a lack of replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

20.5 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

20.6 The precision statement was determined through statistical examination of 24 test results, as reported by six of the seven laboratories (data from one laboratory excluded from precision calculations).

## 21. Keywords

21.1 absorption; accepted reference value; accuracy; bias; board; cellulose; deflection; density; expansion; interlaboratory study; length and width; linear changes; moisture content; modulus of rupture; precision; precision conditions; repeatability; reproducibility; standard deviation; tensile strength; thermal conductivity; thermal insulating materials-board; thickness; transmission-water vapor; transverse strength; water absorption

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C16-1043. Contact ASTM Customer Service at service@astm.org.

**TABLE 3 Modified Modulus of Rupture (psi)**

| Material | Average | Repeatability Standard Deviation | Reproducibility Standard Deviation | Repeatability Limit | Reproducibility Limit |
|---|---|---|---|---|---|
| | $\bar{x}$ | sr | sR | r | R |
| A | 288.000 | 27.462 | 34.056 | 76.894 | 95.356 |
| B | 361.583 | 21.785 | 26.127 | 60.998 | 73.156 |
| C | 327.167 | 18.207 | 27.082 | 50.980 | 75.829 |
| D | 393.583 | 27.284 | 37.463 | 76.395 | 104.895 |
| E | 315.250 | 61.108 | 70.905 | 168.301 | 198.534 |

**TABLE 4 Water Absorption, 2-Hour (Percent by Volume)**

| Material | Average | Reproducibility Standard Deviation | Reproducibility Limit |
|---|---|---|---|
| | $\bar{x}$ | $S_R$ | R |
| A | 4.022 | 0.380 | 1.063 |
| B | 1.554 | 0.443 | 1.240 |
| C | 3.556 | 0.520 | 1.457 |
| E | 3.539 | 0.710 | 1.989 |