Designation: C1104/C1104M – 13a

Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation[1]

This standard is issued under the fixed designation C1104/C1104M; 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 amount of water vapor sorbed by mineral fiber insulation exposed to a high-humidity atmosphere. This test method is applicable only to fibrous base material and binder. The results obtained by this test method cannot be used in describing faced products, since the facing is not tested by using this test method.

1.2 The water vapor sorption characteristics of materials may be affected by conditions such as elevated temperatures or chemical exposures. Values obtained as a result of this test method may not adequately describe the water vapor sorption characteristics of materials subjected to these conditions.

1.3 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.

1.4 *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]

C167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations

C302 Test Method for Density and Dimensions of Preformed Pipe-Covering-Type Thermal Insulation

C303 Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation

C390 Practice for Sampling and Acceptance of Thermal Insulation Lots

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 of Terms Specific to This Standard:*

3.1.1 The term sorption has been adopted for this test method, since mineral fiber insulation may *ab*sorb water within its bulk when viewed macroscopically, while it *ad*sorbs water onto individual fibers on a microscopic scale.

(1) sorption—refers to the taking up and holding of matter by other matter by various processes such as absorption and adsorption.

(2) 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.

(3) 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. Summary of Test Method

4.1 The insulation is dried to a constant weight and exposed to a high-humidity atmosphere for 96 h. The amount of water sorbed from the vapor phase is the difference in specimen weights, and is expressed in either weight or volume percent.

5. Significance and Use

5.1 The sorption of water can result in an increase in weight and a resultant potential degradation of the properties of the insulation.

6. Apparatus

6.1 *Air-circulating oven,* capable of maintaining a temperature between 102° and 121°C [215° and 250°F].

6.2 *Desiccator,* with calcium chloride as a desiccant.

6.3 *Scale,* accurate to ±0.1 % of specimen weight.

6.4 *Environmental test chamber,* capable of maintaining a temperature of 49 ± 2°C [120 ± 3°F] and a relative humidity of 95 ± 3 %.

[1] This test method is under the jurisdiction of Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.33 on Insulation Finishes and Moisture.

Current edition approved Nov. 1, 2013. Published December 2013. Originally approved in 1988. Last previous edition approved in 2013 as C1104/C1104M – 13. DOI: 10.1520/C1104_C1104M-13A.

[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.

6.5 *Steel rule,* graduated in 1 mm or 0.05 in. intervals with depth gauge as described in Test Methods C167.

6.6 *Sealable polyethylene sample bags* of a size large enough to accommodate the test specimens (for blanket, board, or pipe thermal insulations).

6.7 *Non-water-sorbing, non-corrosive tray* with tight-fitting lid measuring at least 15 by 15 cm [6 by 6 in.] (for loose-fill insulations).

7. Sampling and Test Specimens

7.1 Three specimens shall be tested, unless otherwise stated in the appropriate material specification. These are to be obtained from one representative package of insulation. Sampling techniques should be in accordance with Practice C390.

7.2 For blanket and board products, the test specimen shall be of a size that can be conveniently tested in the environmental chamber, but not smaller than 15 by 15 cm [6 by 6 in.] by the full sample thickness. For pipe insulation products, use a 15 cm [6 in.] length and as much of the circumference as can be conveniently tested. For loose-fill products, the test specimen shall consist of sufficient quantity of the material to fill a preweighed container measuring at least 15 by 15 cm [6 by 6 in.], to a nominal depth at its nominal density.

7.3 The insulation shall be tested without facing or jacketing, unless otherwise agreed upon by the purchaser and supplier, or unless otherwise specified by the appropriate material specification.

8. Procedure A, for Blanket, Board, and Pipe Insulation Products

8.1 If it is necessary to determine volume percent, measure the dimensions and calculate the density of the specimens using 8.1.1, 8.1.2, or 8.1.3.

8.1.1 For blanket products, measure the length and width of the specimens using a steel rule. Measure the weight of the specimens. Measure the thickness of the specimens by means of the depth gage as stated in Test Method C167. Calculate the density of the specimens.

8.1.2 For board products, measure the dimensions of the specimens using the test methods stated in Test Method C303.

8.1.3 For pipe products, measure the dimensions of the specimens using the test methods stated in Test Method C302.

8.1.4 Calculate the volume of the specimens. If requested, the volume may be based on the nominal thickness rather than the measured thickness, but this must be included in the report.

8.2 Determine the moisture-free weight of each specimen in the manner described in 8.2.1.

8.2.1 Weigh the specimen. Place the specimen in an air-circulating oven at a temperature of 102° to 121°C [215° to 250°F] for a minimum of 2 h. (See Note 1.) Cool the specimen to room temperature in a desiccator and reweigh. Repeat the process until successive weighings agree to within 0.2 % of the specimen weight obtained in the latest weighing. Record this weight as the moisture-free weight.

NOTE 1—When drying at the specified temperature has been shown to adversely affect the insulation, the specimen may be dried to moisture-free weight in a desiccator at room temperature. However, the drying time between successive weighings should then be extended to at least 24 h.

8.3 Bring the specimens to a uniform temperature in an oven of not less than 60°C [140°F] and then transfer to the environmental chamber. Either suspend the specimens or place on a grid within the chamber in order to ensure air circulation around the specimens. Protect the specimens from condensate dripping from the chamber ceiling by using a slanting false roof immediately above the specimens.

8.4 Allow the specimens to remain in the environmental chamber for 96± 4 h at a temperature of 49° ± 2°C [120°± 3°F] and at a relative humidity of 95 ± 3 %. Then place each specimen in its own pre-weighed sample bag, seal the bag, and remove from the chamber. Allow the bag containing the specimens to cool to room temperature and weigh. Subtract the bag weight from the obtained weight. Record this as the specimen weight after testing.

9. Procedure B, for Loose-Fill Insulation Products

9.1 If it is necessary to determine volume percent, measure the length and width of the pre-weighed sample trays, using a steel rule. Apply the insulation at its nominal or requested thickness and density by pouring or blowing it into the sample tray. Measure the thickness of the specimens by means of a depth gauge. Calculate the volume of the specimens.

9.2 Determine the moisture-free weight of each specimen in the manner described in 9.2.1.

9.2.1 Weigh the sample tray containing the specimen. Place the specimen in an air-circulating oven at a temperature of 102° to 121°C [215° to 250°F] for a minimum of 2 h. (See Note 1.) Place the pre-weighed lid on the sample tray, cool the specimen to room temperature, and reweigh. Remove the lid and repeat the process until successive weighings agree to within 0.2 % of the specimen weight obtained in the latest weighing. Subtract the tray weight from the total obtained weight of the tray and specimen. Record this weight as the moisture-free weight of the specimen.

9.3 Remove the lids and bring the specimens to a uniform temperature of not less than 60°C [140°F], and then transfer to the environmental chamber. Place the trays horizontally within the chamber and place the lids next to the trays. Protect the specimens from condensate dripping from the chamber ceiling by using a slanting false roof immediately above the specimens.

9.4 Allow the specimens to remain in the environmental chamber for 96 ± 4 h at a temperature of 49° ± 2°C [120° ± 3°F] and at a relative humidity of 95 ± 3 %. Then place the lid on each sample tray and remove from the chamber. Allow the tray containing the specimen to cool to room temperature and weigh. Subtract the tray weight from the obtained weight. Record this as the specimen weight after testing.

10. Calculation

10.1 Calculate the percentage water vapor sorption by weight and by volume using Eq 1, Eq 2, and Eq 3.

10.1.1 Water sorbed from the vapor phase,

$$\text{weight percent} = \frac{(W_2 - W_1)}{W_1} \times 100 \quad (1)$$

where:

W_2 = specimen weight after test, and
W_1 = moisture-free weight of specimen.

10.1.2 Water sorbed from the vapor phase,

$$\text{volume percent} = \frac{(W_2 - W_1) \times 100}{(1\ \text{g/cm}^3) \times V} \quad (2)$$

where:

W_2 *and* W_1 = are in grams,
V = is the sample's volume in cm^3, and
1 g/cm³ = is the density of water.

10.1.3 An alternative method of calculating volume percent is shown in Eq 3:

$$\text{Water sorbed from the vapor phase, volume percent} = \frac{(\text{Water sorption, weight percent}) \times (\text{Sample density})}{\text{Density of water}} \quad (3)$$

where the sample density and the density of water are in the same units, such as g/cm^3, lb/ft^3, or $lb/in.^3$

11. Report

11.1 The report shall include the following:

11.1.1 Name and any additional identification of the material tested,

11.1.2 Thickness of the material,

11.1.3 Number of specimens tested,

11.1.4 Density,

11.1.4.1 Measured density (blanket, board, and pipe product),

11.1.4.2 Applied density (for loose fill only),

11.1.5 The average percent water sorption by weight for the specimens, and

11.1.6 The average percent water sorption by volume for the specimens, if requested.

12. Precision and Bias

12.1 *Interlaboratory Test Program*—Interlaboratory studies were run in which randomly drawn test specimens of two materials were tested for moisture sorption. The density of the two materials was 16 kg/m^3 [1 lb/ft^3) and 50 kg/m^3 [3.2 lb/ft^3]. Practice E691 was followed for the design and analysis of the data. All of the test specimens were provided by a single laboratory. The details are given in ASTM Research Report No. RR:C16-1024.[3]

12.1.1 *Test Results*—The precision information given below in units of measurements noted is for the comparision of test results.

12.1.2 *Precision:*

	Light Density Mineral Fiber	Heavy Density Mineral Fiber
Number of Laboratories	3	3
Sorption by Weight, Average Value	2.1%	0.9%
95% repeatability limit (within laboratory)	0.60%	0.18%
95% reproducibility limit (between laboratories)	0.88%	0.52%
Sorption by Volume, Average Value	0.03%	0.05%
95% repeatability limit (within laboratory)	0.01%	0.01%
95% reproducibility limit (between laboratories)	0.02%	0.03%

12.2 The precision of this test method is based on an interlaboratory study of Test Method C1104/C1104M, Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation, conducted in 2012. Six laboratories participated in the study, testing three types of fiber insulation. Every analyst was instructed to report triplicate test results in this study. Practice E691 was followed for the study design; the details are given in ASTM Research Report No. RR:C16-1041.[5]

12.2.1 *Repeatability limit (r)*—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.

12.2.1.1 Repeatability limits are listed in Tables 1-3.

12.2.2 *Reproducibility limit (R)*—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 critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

12.2.2.1 Reproducibility limits are listed in Tables 1-3.

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

12.2.4 Any judgment in accordance with statements 12.2.1 and 12.2.2 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

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C16-1024. Contact ASTM Customer Service at service@astm.org.[4]

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C16-1041. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Percent Water Vapor Sorption by Weight[A]

Material	Average[B] $\bar{x}$	Repeatability Standard Deviation s_r	Reproducibility Standard Deviation s_R	Repeatability Limit r	Reproducibility Limit R
High Density Fiberglass Board	1.4820	0.2277	0.4707	0.6376	1.3181
Light Density Fiberglass Board	1.7597	0.3221	0.9905	0.9020	2.7733
Loosefill Fiberglass	0.9094	0.1085	0.5617	0.3038	1.5727

[A] Precision ranges were calculated for data reported by five laboratories.
[B] The average of the laboratories' calculated averages.

TABLE 2 Percent Water Vapor Sorption by Volume

Material	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	s_r	s_R	r	R
High Density Fiberglass Board	0.0694	0.0086	0.0214	0.0241	0.0600
Light Density Fiberglass Board	0.0316	0.0073	0.0250	0.0205	0.0701
Loosefill Fiberglass	0.0229	0.0045	0.0231	0.0126	0.0647

[A]The average of the laboratories' calculated averages.

TABLE 3 Average Specimen Density (pcf)

Material	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	s_r	s_R	r	R
High Density Fiberglass Board	2.9101	0.1423	0.1423	0.3984	0.3984
Light Density Fiberglass Board	0.7994	0.0706	0.0715	0.1978	0.2003
Loosefill Fiberglass	0.5155	0.0069	0.0492	0.0194	0.1378

[A]The average of the laboratories' calculated averages.

quantities which are applicable to all circumstances and uses. The limited number of materials tested and laboratories reporting usable test results 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. The repeatability limit and the reproducibility limit should be considered as general guides, and the associated probability of 95% as only a rough indicator of what can be expected.

12.2.5 The precision statement was determined through statistical examination of 146 test results, from six laboratories, on three types of fiber insulation.

12.3 *Bias*–No information can be presented on the bias of the procedure in Test Method C1104/C1104M for measuring moisture sorption because no material having an accepted reference value is available.

13. Keywords

13.1 mineral fiber insulation; water vapor sorption