Designation: C 1512 – 07

Standard Test Method for Characterizing the Effect of Exposure to Environmental Cycling on Thermal Performance of Insulation Products[1]

This standard is issued under the fixed designation C 1512; 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 is applicable to preformed or field manufactured thermal insulation products, such as board stock foams, rigid fibrous and composite materials manufactured with or without protective facings. See Note 1 This test method is not applicable to high temperature, reflective or loose fill insulation.

NOTE 1—If the product is manufactured with a facer, test product with facer in place.

1.2 This test method involves two stages: preconditioning and environmental cycling. During the first stage, 25 mm (1 in.) thick specimens are used to separate two environments. Each of these environments has a constant but different temperature and humidity level. During the environmental cycling stage, specimens also divide two environments namely constant room temperature/humidity on one side and cycling temperature/ambient relative humidity on the other side.

1.3 This test method measures the ability of the product to maintain thermal performance and critical physical attributes after being subjected to standardized exposure conditions. A comparison is made between material properties for reference specimens stored in the laboratory for the test period and specimens subjected to the two-stage test method. To eliminate the effect of moisture from the comparison, the material properties of the latter test specimens are determined after they have been dried to constant weight. The average value determined for each of the two sets of specimens is used for comparison.

1.4 Different properties can be measured to assess the effect of environmental factors on thermal insulation. This test method requires that thermal resistance be determined based upon an average for three specimens measured after completing the test. Secondary elements of this test method include visual observations such as cracking, delamination or other surface defects, as well as the change in moisture content after each of the two stages of exposure prescribed by the test method.

1.5 Characterization of the tested material is an essential element of this test method. Material properties used for characterization will include either compressive resistance or tensile strength values. The compressive resistance or tensile strength is measured on two sets of specimens, one set conditioned as defined in 1.2 and a set of reference test specimens taken from the same material batch and stored in the laboratory for the whole test period. For comparison, an average value is determined for each of the two sets of specimens.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 165 Test Method for Measuring Compressive Properties of Thermal Insulations
C 168 Terminology Relating to Thermal Insulation
C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
C 303 Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation
C 518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
C 870 Practice for Conditioning of Thermal Insulating Materials
C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
D 1621 Test Method for Compressive Properties Of Rigid Cellular Plastics
D 1623 Test Method for Tensile and Tensile Adhesion

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

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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.

Properties of Rigid Cellular Plastics

3. Terminology

3.1 *Definitions*—Terms used in this test method are defined in Terminology C 168 with the exceptions included as appropriate.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *compressive resistance*—the compressive load per unit of original area at the specified deformation. See Test Method C 165.

3.2.2 *moisture accumulation*—an increase in the average moisture content resulting from a specified exposure to conditions facilitating moisture ingress into the material.

3.2.3 *preconditioning*—a procedure which subjects test specimens to standardized one directional thermal gradient.

3.2.4 *thermal performance*—comparison of thermal resistance of test specimens before and after cycling.

4. Summary of Test Method

4.1 To reduce the testing period, this procedure involves two stages:

4.1.1 *Stage 1*—Preconditioning under constant thermal gradient and relative humidity to accelerate ingress of moisture into the test specimen.

4.1.2 *Stage 2*—Exposure to constant temperature and relative humidity on one side of test specimens with cycling environmental conditions on the other side that include freeze-thaw exposure.

5. Significance and Use

5.1 Exposing a specimen to conditions of one-directional environmental cycling can increase its moisture content until a decrease in material properties occurs (at a specific number of cycles). Such a test could be inappropriate due to the number of cycles required to cause a decrease in material properties since product performance issues often arise only after many years of exposure. The use of a preconditioning procedure is not intended to duplicate expected field performance. Rather the purpose is to increase the moisture content of test materials prior to subjecting to them to environmental cycling.

5.2 The most important aspect of the preconditioning procedure is non-uniform moisture distribution in the specimen. The heat flow is one directional causing moisture flow towards the cold side resulting in zones of dry material on the warm side and high moisture content on the cold side. (Whether the high moisture content zone is located right at the cold surface of the specimen or at some distance from this surface depends upon temperature oscillation and ability of the cold surface to dry outwards). Because the preconditioning procedure involves thermal gradient, this preconditioning procedure results in a distribution of moisture content that may occur under field exposure conditions. However, the resulting moisture content may differ significantly from that which may be demonstrated in typical product applications.

5.3 The preconditioning results in accumulation of moisture in the thermal insulation resulting from the simultaneous exposure to a difference in temperature and water vapor pressure. This test method is not intended to duplicate field exposure. It is intended to provide comparative ratings. As excessive accumulation of moisture in a construction system may adversely affect its performance, the designer should consider the potential for moisture accumulation and the possible effects of this moisture on the system performance.

6. Apparatus

6.1 The room where the apparatus is placed shall be maintained at a temperature and relative humidity of 24 ± 3°C (75 ± 5°F) and 50 ± 10 %.

6.2 *Freeze-Thaw Chamber*, capable of maintaining an air temperature of -15 ± 3°C (5 ± 5°F) over an extended period of time. The design of the apparatus should ensure that the temperature of the upper surface of the sheet metal located below the insulation specimen (measured in the center of the pan) be not higher than -4°C (25°F) when the freezer's air temperature reaches its lower limit. This can be achieved by placing thermal insulation between the metal pan and the specimen frame and/or mixing of air in the cold chamber.

6.3 *Sheet Metal Pan*, placed below the specimens. This pan performs two functions: it equalizes temperature and reduces diffusion of water vapor into the freeze-thaw chamber. The distance between the cold surface of the specimen and the sheet metal should be no less than 6 mm (¼ in.) and no more than 12 mm (½ in). The required space is normally maintained by attaching a support of the required height that is made from 6-mm (¼ in.) thick Plexiglas or other non-absorbing materials on the inside surface of the specimen frame (see Fig. 2).

6.4 *Frame*, that is placed in the door opening of the freezer (see Figs. 1 and 2) or other means of specimen support. Test frames used are made from 6 ± 0.5 mm thick Plexiglas or other non-absorbing material. These frames are used to mount individual test specimens. The selection of the test frame (size of the test specimen) may vary based upon the thermal testing apparatus that is used.

6.5 *Warm Chamber*, above the test specimens that is provided with a heater and a temperature controller capable of maintaining a temperature of 24 ± 2°C (75 ± 3°F) and a humidifier capable of maintaining humidity in the warm chamber of 90 ± 5 %RH.

6.6 *Sensors*, for measuring temperature of the freeze-thaw and warm chambers and relative humidity in the warm chamber.

6.7 *Balance*, capable of weighing mass of maximum 1 kg with precision of 0.01 g.

7. Test Specimens

7.1 Test specimens shall be square in cross-section with a minimum area of 645 cm^2 (100 $in.^2$) and a maximum of 3716 cm^2 (576 $in.^2$). The standard specimen thickness shall be 2.54 cm (1 in.). Care should be taken so that the top and bottom surfaces of the specimens exposed to thermal gradient are parallel with one another and perpendicular to the sides.

7.2 All surfaces of the specimens shall be free from visible flaws or imperfections.

7.3 For comparison, two test specimen sets each consisting of a minimum of three specimens are tested. One set of test specimens are tested after preconditioning and after environmental cycling as described in Section 9. A second set of

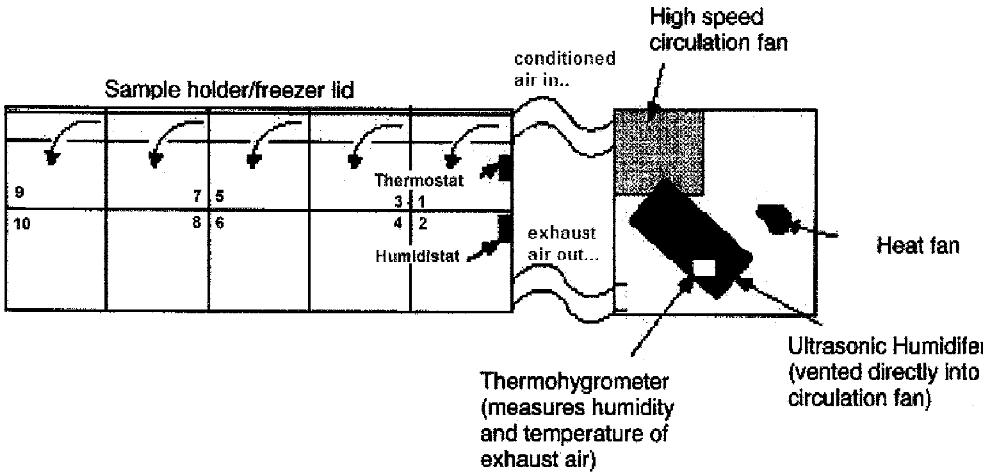

FIG. 1 Plan View of Test Equipment Setup

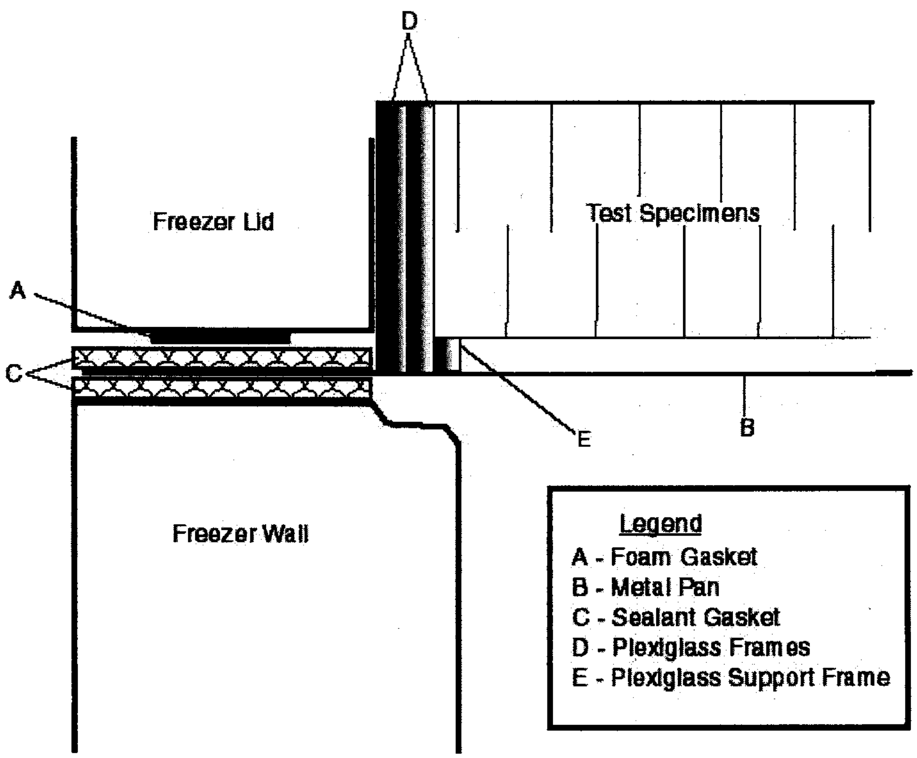

FIG. 2 Vertical Section at Interface Between Freezer Wall and Lid Illustrating Placement of Test Specimens in the Test Frame

reference test specimens are stored in the laboratory for the duration of preconditioning and environmental cycling test before thermal resistance and compressive resistance or tensile strength testing.

8. Conditioning

8.1 Condition the test specimens before testing at 23 ± 2°C (73 ± 4°F) and 50 ± 5 %RH relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618.

9. Procedure

9.1 Condition specimens to constant mass in accordance with Practice C 870 before testing. Measure the dimensions and mass of each specimen in accordance with Test Method C 303. Record the initial mass of each specimen prior to subjecting to preconditioning procedure.

9.2 *Testing of Specimens Before and After Environmental Cycling*:

9.2.1 Three specimens shall be tested for thermal resistance value before and after environmental cycling using Test Method C 518 or C 177.

9.2.2 Where applicable, nine specimens shall be tested for compressive resistance before and after environmental cycling using Test Method C 165 or D 1621.

9.2.3 Where applicable, nine specimens shall be tested for tensile strength before and after environmental cycling using Test Method D 1623.

9.3 *Preconditioning*:

9.3.1 Test specimens are preconditioned for 28 days to increase moisture content. This is achieved under conditions of water vapor diffusion associated with a constant thermal gradient. The specimens are dividing two environments, namely:

9.3.1.1 Temperature of 24 ± 2°C (75 ± 3°F) and relative humidity of 90 ± 5 % on warm side, and

9.3.1.2 Temperature of -15 ± 3°C (5 ± 5°F) and ambient relative humidity (uncontrolled relative humidity) on the cold side.

9.3.2 If the specimens are provided with facing, stucco lamina or other protective finishes, these finishes should be placed on the cold side during the preconditioning exposure.

9.3.3 Weigh each specimen after initial preconditioning. Moisture content (% by volume) of the specimen is calculated after completing the preconditioning exposure. Normally the specimens are returned to the same equipment but conditions on the cold side are changed and cycling under environmental conditions which include freeze-thaw cycling on the cold side proceeds.

9.4 *Environmental Cycling Conditions*:

9.4.1 Place test specimens in the test frame (Fig. 2) and seal the edges of the test specimens to prevent passage of air around the edges.

9.4.2 Test specimens shall be placed for 20 days (40 cycles) separating two environments:

9.4.2.1 Warm chamber where temperature and relative humidity are maintained at 24 ± 2°C (75 ± 3°F) and 90 ± 5 %RH; and

9.4.2.2 Environmental cycling chamber where conditions require temperature cycling between two levels: -15 ± 3°C (5 ± 5°F) and 15 ± 3°C (59 ± 5°F). The total cycling period is twelve hours, divided equally into cold and warm exposures. The warm exposure (at least 4 h at temperature higher than 5°C) is ended with the transition period of no longer than 2 h. During the cold exposure stage of the cycle, air in the chamber is cooled to -15 ± 3°C (5 ± 5°F). The cold exposure period is ended with a similar transition period (to reach an air temperature higher than 5°C) during a period of 2 h.

9.4.3 Weigh each specimen after completion of environmental cycling and calculate moisture content (% by volume). Condition specimens to constant mass in accordance with 9.1 and subject to testing in accordance with 9.2.

10. Report

10.1 The test report shall include the following information, including references to applicable test methods:

10.1.1 The date of the report.

10.1.2 The name, address and identification of the testing laboratory.

10.1.3 The manufacturer of the material, the date of manufacture and the date of receiving samples.

10.1.4 Number of samples received and the number of specimens tested in respective categories.

10.1.5 The name or identification of the material tested and description of facers (if any).

10.1.6 The method of specimen preparation.

10.1.7 The type and size of the preconditioning set-up and the preconditioning conditions.

10.1.8 The moisture content (% by volume) of each test specimen after preconditioning and cycling.

10.1.9 Average and standard deviation of these values at the end of preconditioning stage.

10.1.10 The method of sealing around the test specimen.

10.1.11 Average of the test conditions such as minimum and maximum temperatures in the freezing cabinet, the difference in temperature of air in the freezing cabinet and the surface of the sheet metal facing test specimens.

10.1.12 The moisture content, in kg/m^3 for each test specimen and the average and standard deviation of these values at the end of the testing stage.

10.1.13 Individual and average thermal resistance values after drying for three specimens (tested material) subjected to preconditioning and environmental cycling.

10.1.14 Individual and average thermal resistance values for three specimens (reference material) from the same production batch stored in the laboratory for the period of testing.

10.1.15 The method of Heat Flow Meter Apparatus calibration.

10.1.16 The compressive resistance of nine specimens cut from Series 1 specimens and nine specimens cut from Series 2 specimen.

10.1.17 The average and standard deviation for compressive resistance values measured on each series.

11. Precision and Bias

11.1 The reproducibility precision of this test method is in the process of being established. Extensive measurements performed in two laboratories are used to generate the following estimates of repeatability precision.

11.2 As the worst-case scenario, measurements on ten expanded polystyrene specimens, each approximately 25-mm thick and taken from different products of similar density are reported in Table 1. Laboratory 1 showed average moisture contents of 2.1 % by volume after preconditioning and 2.35 % by volume after climatic cycling and laboratory 2 had measured average moisture contents of 3.5 % by volume after preconditioning and 3.81 % by volume after climatic cycling. The standard deviations for the ten EPS specimens before and after environmental cycling are also provided.

12. Keywords

12.1 environmental cycling; thermal insulation

TABLE 1 Moisture Content and Standard Deviation

Moisture Content (% by Volume)	Laboratory 1 Before Cycling	Laboratory 1 After Cycling	Laboratory 2 Before Cycling	Laboratory 2 After Cycling
Specimen 1	1.05	1.42	3.8	4.4
Specimen 2	2.79	2.94	3.3	2.7
Specimen 3	2.86	2.75	3.9	3.5
Specimen 4	2.30	2.95	3.3	3.7
Specimen 5	2.75	2.74	3.6	4.5
Specimen 6	0.84	1.46	2.9	2.8
Specimen 7	2.33	3.01	3.4	4.4
Specimen 8	2.61	2.97	3.6	4.5
Specimen 9	2.17	1.92	3.6	3.5
Specimen 10	1.32	1.30	3.6	4.1
Average	2.10	2.35	3.5	3.81
Standard Deviation	0.76	0.73	0.29	0.68