Designation: E 861 – 94 (Reapproved 2001)

Standard Practice for Evaluating Thermal Insulation Materials for Use in Solar Collectors[1]

This standard is issued under the fixed designation E 861; 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 practice sets forth a testing methodology for evaluating the properties of thermal insulation materials to be used in solar collectors with concentration ratios of less than 10. Tests are given herein to evaluate the pH, surface burning characteristics, moisture adsorption, water absorption, thermal resistance, linear shrinkage (or expansion), hot surface performance, and accelerated aging. This practice provides a test for surface burning characteristics but does not provide a methodology for determining combustibility performance of thermal insulation materials.

1.2 The tests shall apply to blanket, rigid board, loose-fill, and foam thermal insulation materials used in solar collectors. Other thermal insulation materials shall be tested in accordance with the provisions set forth herein and should not be excluded from consideration.

1.3 The assumption is made that elevated temperature, moisture, and applied stresses are the primary factors contributing to the degradation of thermal insulation materials used in solar collectors.

1.4 Solar radiation is not considered a contributing factor since insulating materials are not normally exposed to it.

1.5 *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:*

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus[2]

C 209 Test Methods for Cellulosic Fiber Insulating Board[2]

C 356 Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat[2]

C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation[2]

C 518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus[2]

C 553 Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications[2]

C 687 Practice for Determination of the Thermal Resistance of Loose-Fill Building Insulation[2]

D 2842 Test Method for Water Absorption of Rigid Cellular Plastics[3]

E 84 Test Method for Surface Burning Characteristics of Building Materials[4]

3. Summary of Practice

3.1 The following factors, in most cases, should be considered when evaluating insulation materials for use in solar collectors. Design considerations should dictate priorities in material test evaluations:

Factor	Reference Section
pH	7.2
Surface Burning Characteristics	7.3
Moisture Adsorption	7.4
Water Absorption	7.5
Thermal Resistance	7.6
Linear Shrinkage (or Expansion)	7.7
Hot Surface Performance	7.8
Chemical Compatibility	7.9
Outgassing	7.10
Durability	7.11

[1] These test methods are under the jurisdiction of ASTM Committee E44 on Solar, Geothermal, and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.05 on Solar Heating and Cooling Subsystems and Systems.

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[2] *Annual Book of ASTM Standards,* Vol 04.06.

[3] *Annual Book of ASTM Standards,* Vol 08.02.

[4] *Annual Book of ASTM Standards,* Vol 04.07.

4. Significance and Use

4.1 The exposure conditions in solar collectors, especially under stagnation conditions, may degrade the performance of thermal insulation materials. This practice sets forth a methodology for evaluating the degree of degradation, if any, of the thermal insulation materials after exposure to simulated in-service conditions.

4.2 This practice is also intended to aid in the assessment of long-term performance by comparative testing of insulation materials. However, correlations between performance under laboratory and actual in-service conditions have not been established.

4.3 This practice also sets forth criteria that shall be considered in the selection and specification of thermal insulation materials. One such criterion is surface burning characteristics (Test Method E 84), which is used by many code officials as a reference. This practice does not represent that the numerical values obtained in any way reflect the anticipated performance of the thermal insulation under actual fire conditions.

5. Sampling and Test Specimens

5.1 Representative specimens shall be selected at random from the original sample lot for each test condition.

5.2 At least three representative specimens shall be measured for each property tested unless otherwise stipulated in a particular test.

5.3 The size and shape of the representative specimens shall be as specified in the property measurement test.

5.4 A separate set of test specimens shall be prepared for each test.

6. Conditioning

6.1 Unless otherwise specified, maintain the test specimens in a conditioned space at 24°C (75 ± 5°F) and 50 ± 5 % relative humidity for at least 48 h before testing.

6.2 Maintain test samples in the conditioned space until removed to perform a particular test sequence.

7. Procedure

7.1 Conduct all the tests described in 7.2-7.11. The sequence of testing is optional.

7.2 *pH*:

7.2.1 Measure the pH of a mixture consisting of the insulation material and water with a pH meter using the following procedure:

7.2.1.1 Pulverize a sample of approximately 5 g of the insulation to pass through a 4760-µm sieve.

7.2.1.2 Mix the pulverized sample with 100 mL of distilled water at 24°C (75 ± 5°F) in a 500-mL glass beaker.

7.2.1.3 Stir the mixture, using a glass rod, and allow to stand for 1 h at 24°C (75 ± 5°F).

7.2.1.4 Measure the pH to the nearest 0.1 unit.

7.2.2 Calibrate the pH meter and electrodes before each testing sequence using standard buffer solutions. Buffer solution pH shall be within ± 2 pH units of the expected measured pH.

7.3 *Surface Burning Characteristics*—Determine flame spread and smoke-developed classifications of the insulation material in accordance with Test Method E 84.

7.4 *Moisture Adsorption*—Determine the moisture adsorption of the insulation material in accordance with Specification C 553. Express the quantity of moisture (water) adsorbed by the insulation material as a percentage by mass and by volume.

7.5 *Water Absorption*— Determine the water absorption of the insulation material in accordance with Methods C 209 or Test Method D 2842 as applicable. Express the quantity of water absorbed by the insulation material as a percentage by mass and by volume.

7.6 *Thermal Resistance*—Determine the thermal resistance of the insulation material in accordance with Test Methods C 518, C 177, or Practice C 687, as applicable.

7.7 *Linear Shrinkage*— Determine the linear shrinkage (or expansion) of the insulation material in accordance with Test Method C 356, at the expected maximum in-service temperature, including stagnation conditions.

NOTE 1—Maximum in-service temperatures, including stagnation conditions must be determined by testing the solar collector design under consideration.

7.8 *Hot Surface Performance*—Determine the hot surface performance in accordance with Test Method C 411. Test materials at the expected maximum in-service temperature, including stagnation conditions. See Note 1.

7.9 *Chemical Compatibility with Adjoining Material*:

7.9.1 Cut samples of adjoining materials to be evaluated to 100 by 40 mm (3.7 by 1.5 in.) from stock materials and wash thoroughly with cr grade isopropyl alcohol. After drying overnight in a desiccator, weigh the samples to at least four significant figures. Then photograph the specimens at a magnification of 200×.

7.9.1.1 Cut samples of the insulation material to be evaluated to 145 by 90 mm (5.7 by 3.5 in.) along with a surgical cotton control sample that has been thoroughly washed with cp grade isopropyl alcohol.

7.9.1.2 Prepare test samples of the insulation material and cotton control using one piece of adjoining material to two pieces of insulation (or control) forming a sandwich composite. Take care to ensure intimate contact.

7.9.2 Subject all the test samples to 49°C (120 ± 3°F) and 95 ± 3 % relative humidity for 96 h. Dry the test material in a desiccator, weigh, and record the change in mass. Photograph the test materials in contact with both the insulation and the cotton control at 200× magnification of any distressed areas. Compare and contrast these photographs and record the differences.

7.9.2.1 Although it is recognized that this test method is appropriate for identifying chemical incompatibility in most insulation materials, it must be stated that other temperature and humidity parameters will also induce distress.

7.10 *Outgassing (Volatile Condensibles)*—Release of volatiles from the insulation materials, in some cases, may be a significant factor that can effect the transmittance of a cover plate, or the properties of the absorber itself, or both. It is expected that elevated temperatures or reactions, or both, between materials may cause outgassing. A generally applicable test is not presently available to evaluate effects of outgassing products. It is essential however, that this factor be recognized.

7.11 *Durability*:

7.11.1 Evaluate the durability of the test sample by measuring the thermal resistance of the insulation material in accordance with 7.6 before and after exposure to aging.

7.11.2 Measure specimens at least 300 × 300 mm (12 × 12 in.).

7.11.3 Place the specimen in an aluminum pan as shown in Fig. 1.

7.11.4 Cover the pan and expose the specimens to maximum in-service temperature, including stagnation conditions (see Note 1), for 30 days in an electric oven.

7.11.5 Determine the change in thermal resistance in accordance with Test Methods C 177, C 518, or Practice C 687, as applicable, after exposure to the aging test.

7.11.6 Examine the specimen and record any visible changes that may have occurred during accelerated aging. Observe and record changes, such as cracking, decomposition, delamination, dimensional variations, and warpage, as to number and extent of occurrences.

8. Report

8.1 The report shall include the following:

8.1.1 *Identification of the Insulation Material*:

8.1.1.1 Name of manufacturer,

8.1.1.2 Generic nature of insulation material,

8.1.1.3 Density, and

8.1.1.4 Thickness.

8.1.2 *pH*—Report measured pH from 7.2 to the nearest 0.1 pH unit.

8.1.3 *Surface Burning Characteristics*—Report test results as calculated by Section 8 of Test Method E 84.

8.1.4 *Moisture Adsorption*—Report percentage by mass and by volume as calculated by 15.4 of Specification C 553.

8.1.5 *Water Absorption*— Report percentage by mass and by volume as calculated by 13.4 of Methods C 209 or by Section 9 of Test Method D 2842.

8.1.6 *Thermal Resistance*:

8.1.6.1 Report test method used, test temperature differential, density, and thickness.

8.1.6.2 Report thermal transmission properties in accordance with 9.3 of Test Method C 177, 9.2 of Test Method C 518, or Section 6 of Practice C 687.

8.1.7 *Linear Shrinkage (or Expansion)*:

8.1.7.1 Report test temperature used in 7.7.

8.1.7.2 Report linear shrinkage (or expansion) as calculated by Section 6 of Test Method C 356 and observations in accordance with 7.2.4, 7.1.5, 7.1.6, 7.1.7, and 7.1.8 of Test Method C 356.

8.1.8 *Hot Surface Performance*:

8.1.8.1 Report test temperature used in 7.8.

8.1.8.2 Report warpage as calculated by Section 6 of Test Method C 411 and observations in accordance with 7.1.8, 7.1.9, 7.1.12, 7.1.13 of Test Method C 411.

8.1.9 *Chemical Compatibility with Adjoining Materials*—Report observed differences from 7.9.2 and include photographs.

8.1.10 *Durability Results*:

8.1.10.1 Report test temperature used in 7.11.4.

8.1.10.2 Report the change in thermal resistance expressed as a percentage from 7.11.5.

8.1.10.3 Report recorded observations from 7.11.6.

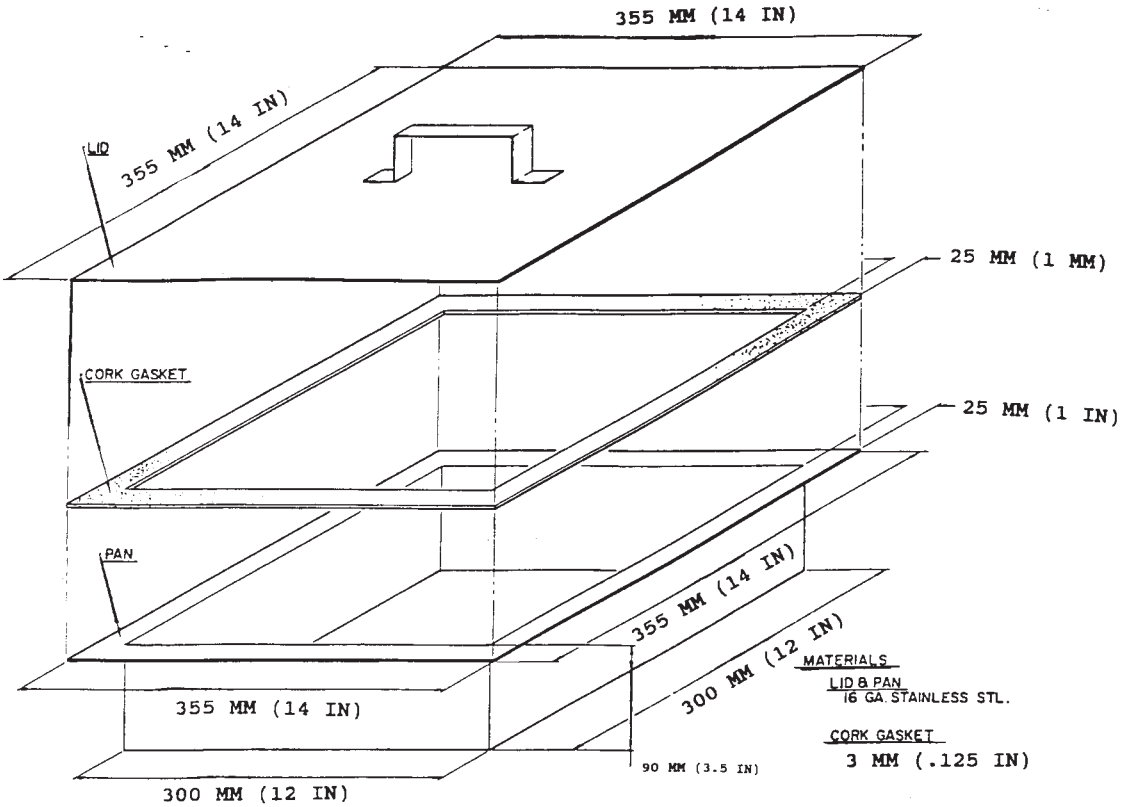

FIG. 1 Aluminum Pan for Testing Durability

9. Keywords

9.1 chemical compatibility; degradation; durability; insulation; solar collectors; stagnation; thermal insulation