This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: C1859 – 23

Standard Practice for Determination of Thermal Resistance of Pneumatically Installed Loose-Fill Building Insulation (Behind Netting) for Enclosed Applications of the Building Thermal Envelope[1]

This standard is issued under the fixed designation C1859; 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 presents a laboratory guide to determine the thermal resistance of pneumatically installed loose-fill building insulations for enclosed applications of the building thermal envelope behind netting at mean temperatures between –10 and 35°C (14 to 95°F).

1.2 This practice applies to a wide variety of loose-fill thermal insulation products including but not limited to fibrous glass, rock/slag wool, or cellulosic fiber materials and any other insulation material that can be installed pneumatically. It does not apply to products that change their character after installation either by chemical reaction or the application of binders, adhesives or other materials that are not used in the sample preparation described in this practice, nor does it consider the effects of structures, containments, facings, or air films.

1.3 Since this practice is designed for reproducible product comparison, it measures the thermal resistance of an insulation material which has been preconditioned to a relatively dry state. Consideration of changes of thermal performance of a hygroscopic insulation by sorption of water is beyond the scope of this practice.

1.4 The sample preparation techniques outlined in this practice do not cover the characterization of loose-fill materials intended for open applications and not intended for spray-applied applications.

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

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

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

C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus

3. Terminology

3.1 Unless otherwise stated, the terms and definitions found in Terminology C168 are applicable herein.

4. Significance and Use

4.1 The thermal resistance, R, of an insulation is used to describe its thermal performance.

4.2 The thermal resistance of an insulation is related to the density and thickness of the insulation. It is desirable to obtain test data on thermal resistances at thicknesses and densities related to the end uses of the product.

[1] This practice is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurement.

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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.

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4.3 In normal use, the thickness of these products range from less than 100 mm (4 in.) to greater than 150 mm (6 in.). Installed densities depend upon the product type, the installed thickness, the installation equipment used, the installation techniques, and the geometry of the insulated space.

4.4 Loose-fill insulations provide coverage information using densities selected by manufacturers to represent the product installed densities. Generally, it is necessary to know the product thermal performance at a representative density.

4.5 When applicable specifications or codes do not specify the nominal thermal resistance level to be used for comparison purposes, a recommended practice is to use the Rsi (metric) = 2.65 m F/Btu]) label density and thickness for that measurement.

4.6 If the density for test purposes is not available from the coverage chart, a test density shall be established by use of applicable specifications and codes or, if none apply, agreement between the requesting body and the testing organization.

4.7 Generally, thin sections of these materials are not uniform. Thus, the test thickness must be greater than or equal to the product's representative thickness if the results are to be consistent and typical of use.

NOTE 1—The representative thickness is specific for each product and is determined by running a series of tests in which the density is held constant but the thickness is increased. The representative thickness is defined here as that thickness above which there is no more than a 2 % change in the resistivity of the product. The representative thickness is a function of product blown density. In general, as the density decreases, the representative thickness increases. Fortunately, most products are designed to be blown over a small range of densities. This limited range yields a range of representative thicknesses between 75 to 150 mm (3 to 6 in.) for most products. To simplify the process for this practice, the representative thickness for the C1859 tests is considered 87.5 mm (3 ½ in). All thermal testing on this product is conducted at a thickness that is greater or equal to the representative thickness.

4.7.1 For this practice, the minimum test thickness shall be 87.5 mm (3 ½ in.). If the test is to represent an installation at a lesser thickness, the installed thickness shall be used.

4.8 For purposes of this practice, it is acceptable to estimate the thermal resistance at any thickness from the thermal resistivity obtained from tests on the product at the minimum test thickness (see 4.7.1) and at the density expected for the proposed thickness.

4.9 In principle, any of the standard methods for the determination of thermal resistance are suitable for loose-fill products. These include Test Methods C177, C518, C1114, and C1363. This practice was developed in relationship to Test Method C518 specimen size and geometry. For this reason, Test Method C518 is preferred. Test Methods C177, C1114, and C1363 are acceptable but changes to specimen size and geometry are possible.

4.10 The thermal resistance of low-density insulations depend upon the direction of heat flow. Unless otherwise specified, tests shall be performed for the maximum heat flow condition, that is, a horizontal specimen with heat flow-up.

4.11 Specimens shall be prepared in a manner consistent with the intended installation procedure. Products for pneumatic installation behind netting shall be pneumatically applied (blown) using the manufacturer's installation instructions and netting specified.

5. Apparatus

5.1 Thermal test apparatus used for this practice shall meet these requirements.

5.1.1 *Conformance to Standards*—The apparatus shall conform to all requirements of the ASTM thermal test method used.

5.1.2 *Size and Error*—The apparatus shall be capable of testing specimens up to at least 150-mm (6-in.) thickness with an estimated error not greater than 1 % attributed to thickness/guard dimensions. (Parametric studies using a mathematical model of the proposed apparatus will give insight to this evaluation. For example, see Table 1 in the 1976 edition of Test Method C518.[3]

NOTE 2—Thermal test apparatus in use for this practice shall have overall plate dimensions of 457 to 1220 mm (18 to 48 in.) square with metering areas 152 to 457 mm (6 to 18 in.) square. Other sizes are acceptable if proper consideration of the size-thickness restrictions as outlined in the test method are observed in their design. (See Practice C1045 for additional discussion.)

5.1.3 *Temperature*—As a minimum, the apparatus shall be capable of testing at a mean temperature of 23.9°C (75°F) with a temperature difference of 20 to 28°C (36 to 50°F). The equipment shall be calibrated at the same temperatures as the test conditions. Some existing test apparatus have been designed to provide measurements over a range of mean temperatures from –20 to 55°C (–4 to 131°F) and for a wider range of temperature differences.

5.1.4 *Humidity*—The absolute humidity within the test apparatus shall be maintained low enough to prevent condensation within the specimen or on the cold plate(s). A maximum 9°C (48°F) dew point is consistent with the recommended material conditioning levels.

5.1.5 *Orientation and Direction of Heat Flow*—The thermal test apparatus shall be capable of testing horizontal specimens with heat flow-up. This orientation represents the most adverse heat flow condition for testing between two solid boundaries.

5.1.6 *Thermal Test Specimen Frame*—The test frame shall be sized to match the test apparatus and shall be made of materials having low thermal conductivity (<0.12 W/m K) and minimum thickness. A thin, thermally insignificant, screen or membrane is stretched across the bottom to support the material. To simulate the actual installation process, a frame holder, test frames (top and bottom half), and a cover assembly are recommended. The frame holder, test frames and cover assembly shall have fixed rigid sides (see Figs. 1-5).

5.2 *Specimen Preparation Equipment:*

5.2.1 *Blowing Machine*—A blowing apparatus is required when pneumatically applied specimens are to be tested. Choose the combination of hopper, blower, and hose size and length that is representative of common use for the application

[3] See Table 1, "Maximum Spacing Between Warm and Cold Plates of Heat Flowmeter Apparatus," of Test Method C518 – 76 published in 1985 Annual Book of ASTM Standards, Vol 04.06.

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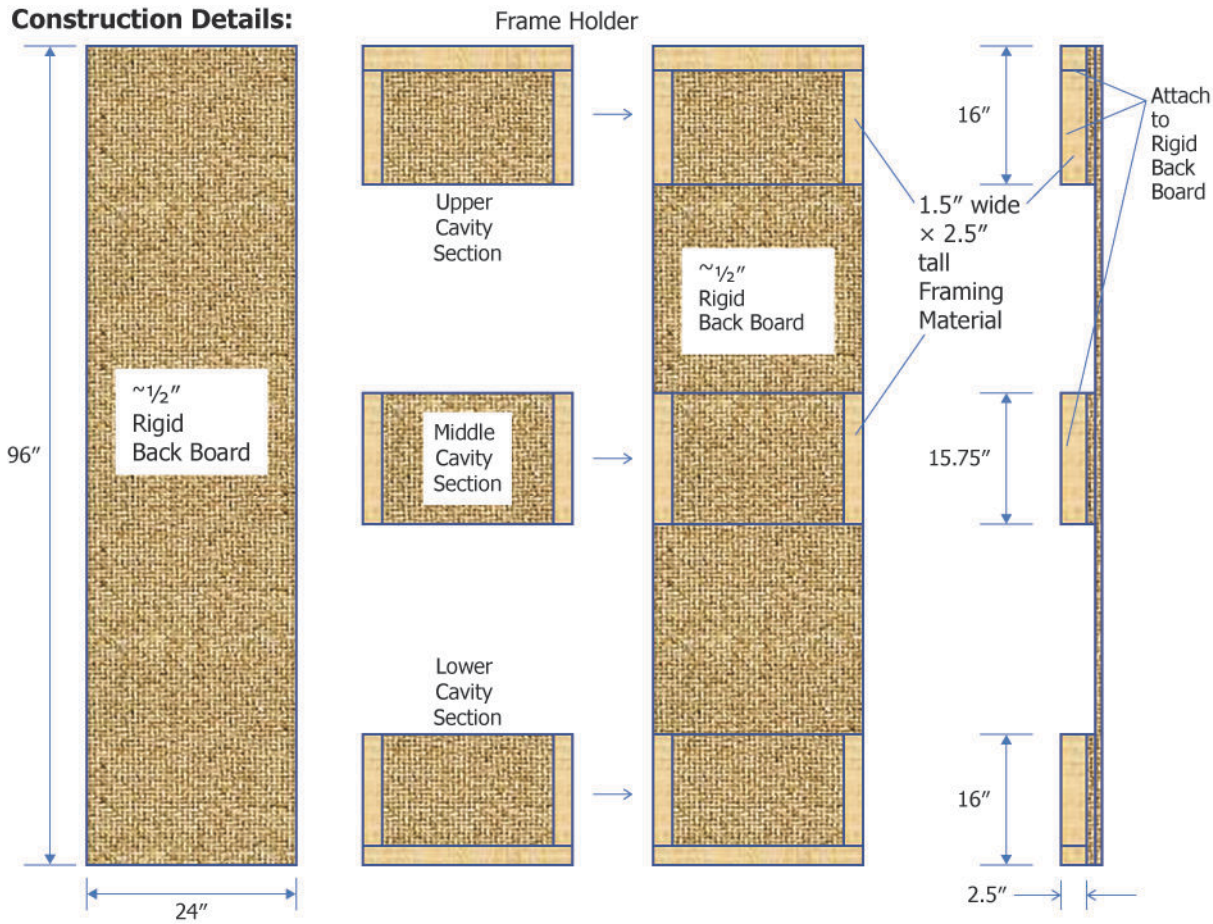

FIG. 1 Recommended Frame Holder (an Example)

of the material to be tested. The following machine specifications have been developed for use with mineral wool and cellulosic materials.

5.2.1.1 *Mineral Fiber Insulations:*

(1) Blowing Machine—A commercial blowing machine with a design capacity for delivering the subject material at a rate between 4 and 15 kg (9 to 33 lb)/min.

(2) Blowing Hose—The machine shall utilize a minimum of 30 m (100 ft) of typical 75 to 100 mm (3 to 4 in.) diameter flexible, internally corrugated blowing hose. The hose shall have no more than eight 90° bends and all bends shall be greater than 1.2-m (4-ft) radius. Before each sample preparation session, examine the hose for material remaining from previous blows. Dislodge any remaining material by mechanically agitating the hose when the machine is running. Repeat as necessary to maintain a clean hose for each specimen.

(3) Insertion Device—The machine shall use a transition coupler to reduce the hose diameter down to 50 to 64 mm (2 to 2.5 in.), with a recommended minimum length of 6 m (20 ft).

NOTE 3—In case of dispute, for mineral fiber insulations a 64 mm (2.5 in.) hose, 46 m (150 ft) long shall be used to prepare the specimens.

5.2.1.2 *Cellulosic Insulations: Blowing Machine*—Use commercial blowing equipment designed for cellulosic material, that is, hopper, blower, and a minimum of 30 m (100 ft) of typical 50 to 75 mm (2 to 3 in.) diameter hose.

NOTE 4—In case of dispute, for cellulosic insulations a 51 mm (2 in.) hose, 30 m (100 ft) long shall be used to prepare the specimens.

5.2.2 *Test Area Specimen Cutter*—A means for isolating the material within the metering area is required for the density determination. The isolated region shall have an area and shape identical to the metering area. Fig. 6 provides an example of a die cutter used for this purpose. The use of a compression plate to compress an area larger than the metering area, prior to metering area material removal is recommended. The compression plate shall extend at least 75 mm (3 in.) beyond the metering area boundary.

5.2.3 *Weighing Devices*—A device is required to weigh the test area material after the thermal test is complete. This device shall determine the test area weight to within 0.5 %. A second device is required during sample preparation and conditioning to determine the sample plus frame weight. This device shall determine the combined weight to within 0.5 %.

5.2.4 *Conditioning Room*—An enclosure held at near constant temperature and humidity is required to stabilize the materials or products prior to testing. The conditions are generally given in product specifications or in other appropriate documents. In the absence of specific directions, conditioning shall be carried out in an atmosphere of 23 ± 2°C (75 ± 4°F) and a relative humidity of 50 ± 5 % (see 5.4).

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