Designation: F3340 – 22

Standard Test Method for Thermal Resistance of Camping Mattresses Using a Guarded Hot Plate Apparatus[1]

This standard is issued under the fixed designation F3340; 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 measurement of the thermal resistance of camping mattresses in conditions of steady-state heat transfer, using a two-plate apparatus. The camping mattress is held under constant compressive force between a guarded hot plate and a cold plate. The primary heat transfer for this method is one dimensional, vertically through the camping mattress thickness. As such this measured thermal insulation value is a repeatable comparative measurement. However, it needs to be noted that this value will not always correlate to actual insulation performance as it is feasible that real-world heat transfer will differ slightly because of additional heat losses possibly involved (for example, edge heat loss, uncovered surface heat loss, compression rate changes or posture changes during sleep).

1.2 This test method is applicable to all types of camping mattresses (for example, inflating air mattress with or without insulation, inflating air mattress with reflective materials, self-inflating open cell foam mattress with or without coring, closed cell non-inflatable foam mats). Auxiliary insulation of any type shall be excluded in the measurement. Auxiliary insulations are any type of material removable from the mattress (for example, sleeping bags, mattress covers).

1.3 The sample thickness shall not exceed the limit determined by the hot plate dimensions stated in 7.1.2.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

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

1.6 *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

D1518 Test Method for Thermal Resistance of Batting Systems Using a Hot Plate

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

2.2 *ISO Standard:*[3]

ISO 8302 Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology C168 and 3.2.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ambient air speed, n*—the air speed of environment immediately surrounding the specimen and apparatus.

3.2.2 *ambient temperature, n*—the air temperature of environment immediately surrounding the specimen and apparatus.

3.2.3 *cold plate, n*—isothermal boundary created by a rigid cooling plate that contacts one side of the specimen and is parallel to the hot plate.

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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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

3.2.4 *guarded hot plate, n*—constant temperature heat source that consists of a central metering plate and primary guards surrounding the sides and backside of the metering plate.

3.2.5 *guards (thermal guards), n*—means to prevent lateral edge heat loss and promote one-dimensional heat flow in the vertical direction through the test sample.

3.2.5.1 *Discussion*—The guards consist of a thermal guard ring surrounding the metering plate and a backplate (counter-heating plate) parallel to the metering plate. The guards are heated independently to maintain the same surface temperature as the metering plate surface temperature.

3.2.6 *homogeneous mattress, n*—a camping mattress with the same composition, average density, and distribution of materials and construction method throughout.

3.2.6.1 *Discussion*—This includes mattresses constructed of a repeating pattern in which the length scale of the pattern is less than half of the width of the metering plate. If it is unclear whether the mattress meets these requirements, consider it a non-homogenous mattress for the purposes of testing.

3.2.7 *metering plate, n*—measurement region of the guarded hot plate that is controllable to a constant temperature and capable of measuring heat loss from its surface in the form of power.

3.2.8 *non-homogeneous mattress, n*—a camping mattress where the composition, average density of materials, and construction method vary from location to location.

3.2.9 *R-value, n*—thermal resistance of a material or a system in inch-pound units: F ft^2 h/Btu.

3.2.9.1 *Discussion—R*-value is only used as a presentation of a converted final material's RSI-value. It shall not be used in any intermediate measurement data conversion or machine calibration.

3.2.10 *RSI-value, n*—thermal resistance of a material or a system in SI units: K m^2/W.

3.2.11 *two-plate guarded hot plate apparatus, n*—apparatus that measures the heat transmission through a specimen from the guarded hot plate to the cold plate.

4. Summary of Test Method

4.1 The specimen is compressed horizontally between a guarded upper hot plate and a lower cold plate. If inflatable, the specimen is inflated to a predetermined internal pressure. The hot plate and cold plate are maintained at fixed temperatures. The ambient temperature is controlled to be equal to the average temperature of the hot plate and cold plate. The heat flux through the specimen is measured during steady-state condition. The thermal resistance is calculated by dividing the temperature difference with the heat flux (see Eq 1).

5. Significance and Use

5.1 The thermal resistance of camping mattresses is an important indicator of insulation performance. This test method establishes criteria to measure this property consistently and in conditions relevant to the application. The measured value can be used for evaluating the thermal insulation performance of the camping mattresses, thus assisting with the product construction and design and providing guidance for consumers in comparing and selecting a mattress.

6. Interferences

6.1 It is feasible that departures from the procedures and conditions of this test method will lead to significantly different test results. It is necessary to report any departures from the procedures and conditions of this test method with the results.

6.2 *Discussion*—Technical knowledge concerning the theory of heat transfer, temperature measurement and testing practices is important for controlling test variables. The causes of measurement uncertainty and variation (Annex A1) shall be understood so that any known errors are corrected or eliminated to the extent possible, and the system is accurately calibrated to ensure measurement accuracy and precision are satisfactory.

7. Apparatus

7.1 *Description*—The apparatus consists of a guarded hot plate, a cold plate, a compression system, a power source, temperature sensors, and a controller. Fig. 1 illustrates the general assembly of the apparatus. Subsections 7.2 to 7.5 describe requirements for each part of the apparatus. The apparatus shall meet the stated tolerance in Section 8 following procedures set forth in Annex A2.

7.1.1 The guarded hot plate and cold plate shall be designed and constructed using principles and construction which are well defined in Test Method C177, Test Method D1518, or ISO 8302. Existing guarded hot plate machines compliant to those standards, that also meet the requirements described in 7.2 and 7.3, can be successfully converted to the apparatus of this standard by adding a compression system.

7.1.2 Additional design consideration shall be given to the maximum specimen thickness limit. Maximum testable specimen thickness depends on plate construction and dimensions. As such, maximum testable thickness shall be stated on all test reports for a given test apparatus. If a test sample exceeds the maximum testable thickness, it shall be excluded for testing on that apparatus. Maximum thickness is determined by using the formula in Section 2.2.1 of ISO 8302 and a 0.5 % threshold of edge heat loss error (see Annex A4).

7.2 *Guarded Hot Plate:*

7.2.1 *Metering Plate*—The heater shall provide uniform temperature across the metering plate surface with a variation of less than 0.2°C when testing materials of R_{ct} greater than 0.1 K m^2/W. The surface of the metering plate shall have an emissivity of 0.9 (as measured at ambient temperature) or greater as to mimic the emissivity of human skin. The minimum dimension of the metering plate shall be 200 mm per side if square, or 200 mm in diameter if circular. The maximum heating capacity is designed to provide adequate heat flux and accuracy in the entire measurable range.

7.2.2 *Thermal Guard Ring*—The combined size of the thermal guard ring and metering plate shall be between 400 and 660 mm per side if square, or between 400 and 660 mm in diameter if circular, to accommodate most standard camping mattresses. The material and construction of the thermal guard ring shall be the same as that of the metering plate. The average