Designation: D1518 – 14

Standard Test Method for Thermal Resistance of Batting Systems Using a Hot Plate[1]

This standard is issued under the fixed designation D1518; 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.

INTRODUCTION

This standard replaces D1518-85, Thermal Transmittance of Textile Materials. This standard provides a method for measuring the thermal resistance (insulation) provided by battings and batting/fabric systems under still air conditions or an air flow condition. Other hot plate standards F1868 and ISO 11092 provide a method for measuring the thermal resistance and evaporative resistance of fabrics and fabric systems. The method for measuring fabric insulation in these standards is comparable to Option 2: Air Velocity Condition in D1518. These standards can be used to compare the thermal properties of textile materials. Manikin standards F1291 and F2370 can be used to measure and compare the thermal resistance and evaporative resistance of clothing systems, respectively. Manikin standard F1720 can be used to measure the insulation provided by sleeping bag systems.

1. Scope

1.1 This test method covers the measurement of the thermal resistance, under steady-state conditions, of battings and batting/fabric systems, and other materials within the limits specified in 1.2. It measures the heat transfer from a warm, dry, constant-temperature, horizontal flat-plate up through a layer of the test material to a cool atmosphere and calculates the resistance of the material. The measurements are made under still air conditions (Option #1) or with a horizontal air flow over the specimen (Option #2).

1.2 For practical purposes, this test method is limited to determinations on specimens of battings and layered batting/fabric assemblies having an intrinsic thermal resistance from 0.1 to 1.5 $K \cdot m^2/W$ and thicknesses not in excess of 50 mm.

1.3 This test method also provides a method for determining the bulk density of the material, the insulation per unit thickness, and the insulation per unit weight.

1.4 The values stated in SI units are to be regarded as standard.

1.5 *This standard does not purport to address the safety concerns associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D3776 Test Methods for Mass Per Unit Area (Weight) of Fabric

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

F1291 Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin

F1494 Terminology Relating to Protective Clothing

F1720 Test Method for Measuring Thermal Insulation of Sleeping Bags Using a Heated Manikin

F1868 Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate

F2370 Test Method for Measuring the Evaporative Resistance of Clothing Using a Sweating Manikin

2.2 *ISO Standards:*[3]

ISO 11092 Textiles–Physiological Effects–Measurement of Thermal and Water-Vapour Resistance Under Steady-State Conditions (Sweating Guarded-Hotplate Test)

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.51 on Conditioning and, Chemical and Thermal Properties.

Current edition approved July 1, 2014. Published August 2014. Originally published as D1518 – 57 T. Last previous edition approved in 2011 as D1518 – 11a. DOI: 10.1520/D1518-14.

[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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

ISO 9073-2 Textile—Test Methods for Nonwovens—Part 2: Determination of Thickness

3. Terminology

3.1 The following terms are relevant to this standard: bulk density, clo, thermal resistance, thermal insulation.

3.2 For terminology relating to thermal resistance and insulation see Terminology F1494.

3.3 For terminology relating to textiles see Terminology D123.

4. Significance and Use

4.1 The thermal resistance of a batting or batting/fabric system is of considerable importance in determining its suitability for use in fabricating cold weather protective clothing, sleeping bags, and bedding systems. The thermal interchange between man and his environment is, however, an extremely complicated subject which involves many factors in addition to the insulation values of fabrics and battings. Therefore, measured thermal insulation values can only indicate relative merit of a particular material.

5. Interferences

5.1 Departures from the instructions of this test method may lead to significantly different test results. Technical knowledge concerning the theory of heat transfer, temperature measurement, and testing practices is needed to evaluate which departures from the instructions are significant. Standardization of the method reduces, but does not eliminate the need for such technical knowledge. Report any departures from the instructions of Test Method D1518 with the results.

6. Apparatus (Fig. 1and Fig. 2)

NOTE 1—The illustrations and captions (including dimensions) shown in Fig. 1and Fig. 2 are provided as informational guidance only and are not to be taken as prescriptive design criteria or construction drawings. The information is given as guidance for possible design concepts only. The final design of equipment, including dimensions of component parts, selection of electrical components and selection of sensors, shall be in conformance with the specifications set forth in the body of this standard.

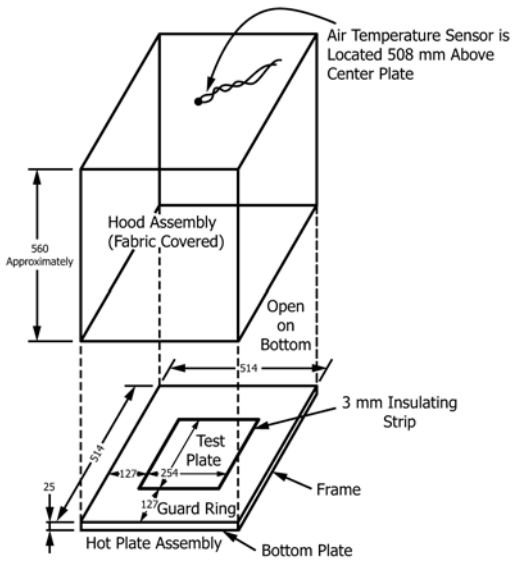

FIG. 1 Hot Plate with Guard Ring and Hood (No Air Velocity Method) Dimensions in mm

6.1 *Hot Plate*—A guarded flat plate composed of a test plate, guard ring, and bottom plate as follows, each electrically maintained at a constant temperature in the range of human skin temperature (33 to 38°C).

6.1.1 *Test Plate*—The test plate portion of the hot plate shall be at least 254 mm (10.0 in.) square and shall be placed at the center of the upper surface of the hot-plate assembly. It shall be made of aluminum or copper with a dull black coating to approximate the emissivity of human skin. The heating element shall be uniformly distributed over the entire area of the test plate, mounted within 3 mm (0.1 in.) of the upper plate surface and well-thermally coupled to it.

6.1.2 *Guard Ring*—The guard ring bordering the test plate shall be at least 127 mm (5.0 in.) in width and shall be of the same thickness, composition, and type of construction as the test plate. It shall be coplanar with the test plate, and shall be separated from it by means of a strip of cork or other suitable insulating material approximately 3-mm (0.1-in.) wide. The guard ring shall be designed to prevent lateral loss of heat from the test plate.

6.1.3 *Bottom Plate*—The bottom plate shall be in a plane parallel to the test plate and guard ring, and at a distance of at least 25 mm (1.0 in.) but not in excess of 75 mm (3.0 in.) beneath them. It shall be separated from the test plate and guard ring and the air pocket formed thereby, or by other means of causing air entrapment. The dimensions offered as suggested design specifications are shown in Fig. 2. The purpose of the bottom plate is to prevent a downward loss of heat from the test plate and guard ring.

6.2 *Temperature Control*—Separate independent temperature control is required for the three sections of the hot plate (test plate, guard section, and bottom plate). Temperature control may be achieved by independent adjustments to the voltage or current, or both, supplied to the heaters using solid state power supplies, solid-state relays (proportional time on), adjustable transformers, variable impedances, or intermittent heating cycles. The test plate, guard, and bottom plate sections shall be controlled to measure the same temperature to within ±0.1°C of each other.

6.3 *Power-Measuring Instruments*—Power to the hot plate test section shall be measured to provide an accurate average over the period of the test. If time proportioning or phase proportioning is used for the power control, then devices that are capable of averaging over the control cycle are required. Integrating devices (watt-hour transducers) are preferred over instantaneous devices (watt meters). Overall accuracy of the power monitoring equipment must be within ±2 % of the reading for the average power for the test period.

6.4 *Temperature Sensors*—Temperature sensors shall be thermistors, thermocouples, resistance temperature devices (RTDs), or equivalent sensors. The test plate, guard section, and bottom plate shall each contain one or more temperature sensors that are mounted flush with the hot plate surface or within 3 mm of the hot plate surface in such a manner that they measure the surface temperature within ±0.1°C.

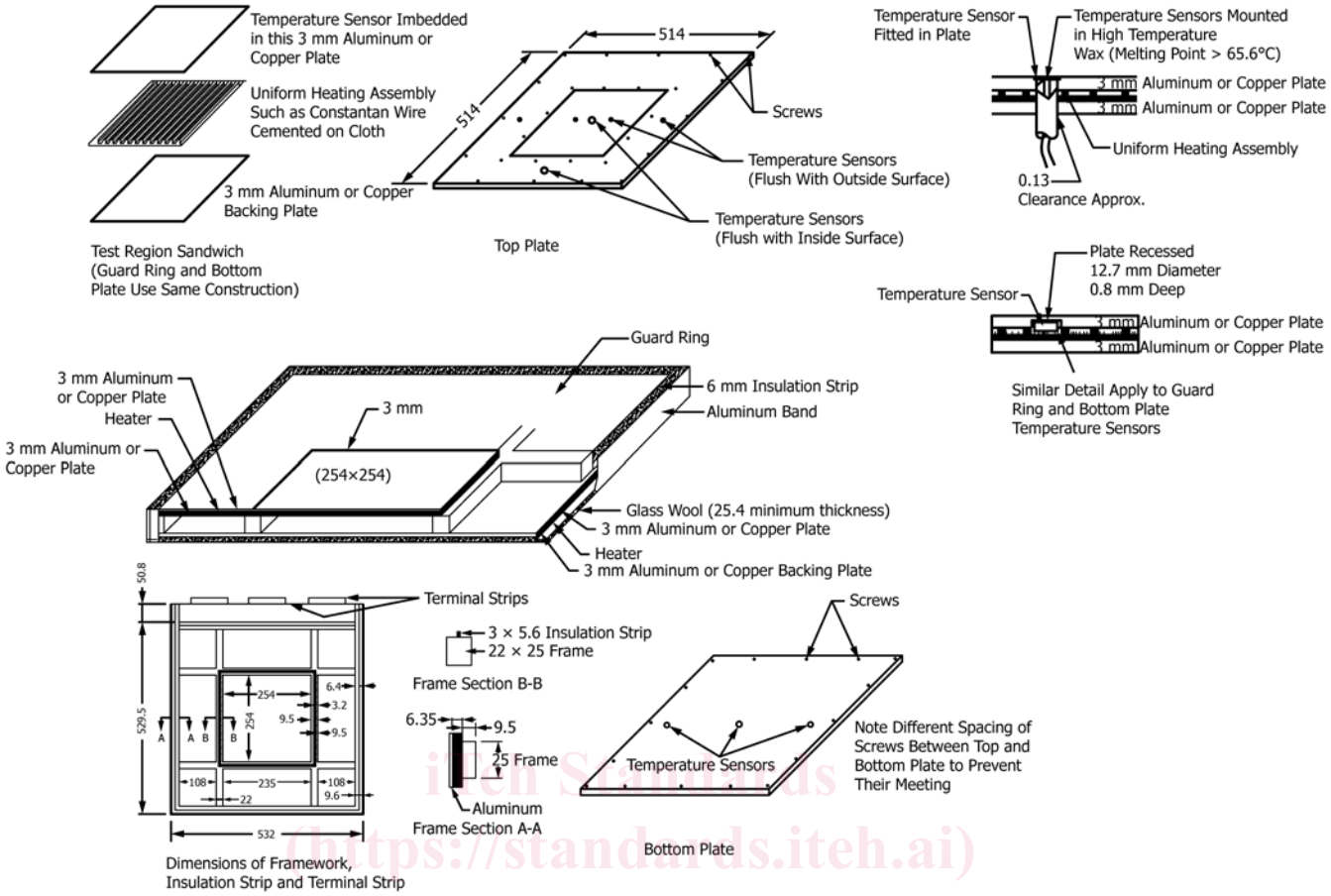

FIG. 2 Example of a Hot Plate Apparatus, Dimensions in mm

6.5 *Controlled Atmosphere Chamber*—The hot plate shall be housed in an environmental chamber that can be maintained at selected temperatures between 1 and 20°C, or lower (see 8.1.2.1.) The test chamber wall temperature shall be ±0.5°C of the air in the chamber. The relative humidity shall be maintained between 20 and 80 %.

6.6 *Hood*—The hot plate shall be covered with a hood to control air flow.

6.6.1 *Option 1: Still Air Condition*—A box-shaped hood made of fabric on a frame with the dimensions shown in Fig. 1 is needed to cover the plate so as to maintain still air conditions over the specimen. The fabric cover must be breathable so that heat buildup is minimized inside the hood. Thin elastic knits have been successfully used to reduce air velocity in this application.

6.6.2 *Option 2: Air Velocity Condition*—An air flow hood is needed that provides 1.0 m/s of air velocity over the batting/fabric specimen in the horizontal direction. The height of the air space above the bare plate or specimen should stay the same from test to test. Therefore, the position of the hood needs to be adjustable relative to the plate surface, or the plate surface needs to be adjustable relative to the fixed position of the hood to accommodate varying sample thicknesses and to prevent air from flowing into the edge of the sample.

6.7 *Measuring Environmental Parameters*—The air temperature, relative humidity, and air velocity shall be measured as follows:

6.7.1 *Relative Humidity Measuring Equipment*—Either a wet-and-dry bulb psychrometer, a dew point hygrometer, or other electronic humidity measuring device shall be used to measure the relative humidity inside the chamber. The relative humidity sensing devices shall have an overall accuracy of at least ±4 %.

6.7.2 *Air Temperature Sensors*—Air temperature sensors with an overall accuracy of ±0.1°C shall be used. The sensors shall have a time constant not exceeding 1 min. Placement of sensors is described under test conditions for each option.

6.7.3 *Air Velocity Indicator*—For Option #2, air velocity shall be measured with an accuracy of ±0.1 m/s using a hot wire anemometer. Air velocity is measured at a point 15 mm (nominal) from the plate surface or from the top of the test specimen surface to the bottom of the anemometer sensing element. The air velocity shall be measured at three positions located along a horizontal line perpendicular to the airflow, including a point at the center of the plate and at points at the centers of the guard section on both sides of the plate. Spatial variations in air velocity shall not exceed ±10 % of the mean value.