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An American National Standard

Standard Test Method for Measuring Thermal Insulation of Sleeping Bags Using a Heated Manikin[1]

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INTRODUCTION

Sleeping bags are used by people in outdoor environments to insulate them from the cold (that is, reduce their body heat loss to the environment). Sleeping bags often are used with ground pads and clothing inside tents that provide additional protection from the environment. The amount of insulation needed in a sleeping bag depends upon the air temperature and a number of other environmental factors (for example, wind speed, radiant temperature, moisture in the air), human factors (for example, a person's metabolic heat production that is affected by gender, age, fitness level, body type, size, position, and movement), and physical factors (for example, amount of body coverage and the quality of the insulating materials). The insulation value, expressed in clo units, then can be used for sleeping bags and sleeping bag systems.

1. Scope

1.1 This test method covers determination of the insulation value of a sleeping bag. It measures the resistance to dry heat transfer from a constant skin temperature manikin to a relatively cold environment. This is a static test that generates reproducible results, but the manikin cannot simulate real life sleeping conditions relating to some human and environmental factors, examples of which are listed in the introduction.

1.2 The insulation values obtained apply only to the sleeping bag, as tested, and for the specified thermal and environmental conditions of each test, particularly with respect to air movement past the manikin.

1.3 *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:*

F 1291 Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *clo*, *n*—unit of thermal resistance (insulation) equal to 0.155°C·m^2/W.

3.1.1.1 *Discussion*—A heavy men's business suit provides 1 clo of insulation.

3.1.2 *dry heat loss*, *n*—heat transferred from the body surface to a cooler environment by means of conduction, convection, and radiation.

3.1.3 *manikin*, *n*—a life-size model of the human body with a surface temperature similar to that of a human being.

3.1.4 *sleeping bag*, *n*—a structure made of down, synthetic fiberfill, shell fabrics, or other materials, or a combination thereof, that is designed for people to use for thermal protection when sleeping (for example, outdoors, tent, cabin).

3.1.5 *thermal insulation*, *n*—any material that increases the resistance to dry heat loss.

3.1.6 *total insulation* (I_T), *n*—the resistance to dry heat loss from the manikin that includes the resistance provided by the sleeping bag and the air layer around the manikin.

3.1.6.1 *Discussion*—Total insulation values (I_T) are measured directly with a manikin. They can be used to compare different sleeping bags, as long as each test is conducted using the same experimental procedures and test conditions.

4. Summary of Test Method

4.1 A nude, heated manikin is placed inside a sleeping bag in a cold environmental chamber.

[1] This test method is under the jurisdiction of ASTM Committee F-8 on Sports Equipment and Facilities and is the direct responsibility of Subcommittee F08.22 on Sleeping Bag Standards.

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[2] *Annual Book of ASTM Standards*, Vol 11.03.

4.2 The power needed to maintain a constant body temperature is measured.

4.3 The total thermal insulation of the sleeping bag (including the resistance of the external air layer) is calculated based on the skin temperature and surface area of the manikin, the air temperature, and the power level.

5. Significance and Use

5.1 This test method can be used to quantify and compare the insulation provided by sleeping bags. It can be used for material and design evaluations.

5.2 The measurement of the insulation provided by clothing (see Test Method D 1291) and sleeping bags is complex and dependent on the apparatus and techniques used. It is not practical in a test method of this scope to establish details sufficient to cover all contingencies. Departures from the instructions in this test method may lead to significantly different test results. Technical knowledge concerning the theory of heat transfer, temperature and air motion measurement, and testing practices is needed to evaluate which departures from the instructions given in this test method are significant. Standardization of the method reduces, but does not eliminate, the need for such technical knowledge. Any departures should be reported with the results.

6. Apparatus

6.1 *Manikin*[3]—Use a supine manikin that is formed in the shape and size of an adult male or female and is capable of being heated to either a constant temperature of 32 to 33°C or a constant mean skin temperature of 32 to 33°C, with a skin temperature distribution similar to that of a human being.

6.1.1 *Size and Shape*—Construct the manikin to simulate the body of a human being, that is, construct a head, chest/back, abdomen/buttocks, arms, hands, legs, and feet. Total surface area shall be 1.8 ± 0.3 m^2, and height shall be 180 ± 10 cm. Any departures from this description should be reported.

6.1.2 *Surface Temperature*—Construct the manikin so as to maintain a constant temperature distribution over the entire nude body surface with no local hot or cold spots. Ensure that the mean skin temperature of the manikin is 32 to 33°C. It is recommended that the average temperature of the hands and feet be lower (26 to 29°C). Do not allow local deviations from the mean skin temperature to exceed ±3°C, except in the extremities. Evaluate temperature uniformity of the nude manikin at least once annually using an infrared thermal imaging system, a surface (contact) temperature probe, or equivalent method. This procedure also should be repeated after repairs or alterations are completed that could affect temperature uniformity, for example, replacing a heating element.

6.2 *Power-Measuring Instruments*—Measure the power to the manikin so as to give an accurate average over the period of a test. If time proportioning or phase proportioning is used for power control, then devices that are capable of averaging over the control cycle are required. Integrating devices (watt-hour meters) 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. Since there are a variety of devices and techniques used for power measurement, do not provide specific calibration procedures. Develop and document an appropriate power calibration procedure.

6.3 *Equipment Measuring the Manikin's Skin Temperature*—The mean skin temperature may be measured with point sensors or distributed temperature sensors.

6.3.1 *Point Sensors*—Point sensors may be thermocouples, resistance temperature devices (RTDs), thermistors, or equivalent sensors. Ensure that they are no more than 3-mm thick and are well bonded, both mechanically and thermally, to the manikin's surface. Bond lead wires to the surface or pass through the interior of the manikin, or both. Distribute the sensors so that each one represents the same surface area or area-weight each sensor temperature when calculating the mean skin temperature for the body. A minimum of 15 point sensors are required. It is recommended that a sensor be placed on the head, chest, back, abdomen, buttocks, and both the right and left upper arm, lower arm, hand, thigh, calf, and foot.

6.3.2 *Distributed Sensors*—If distributed sensors are used (for example, resistance wire), then the sensors must be distributed over the surface so that all areas are equally weighted. If several such sensors are used to measure the temperature of different parts of the body, then their respective temperatures should be area-weighted when calculating the mean skin temperature. Distributed sensors must be small in diameter (that is, less than 1 mm) and firmly bonded to the manikin surface at all points.

6.4 *Controlled Environmental Chamber*—Place the manikin in a chamber at least 3 × 2 × 2.6 m in dimension that can provide uniform conditions, both spatially and temporally.

6.4.1 *Spatial Variations*—Do not exceed the following: air temperature ±1.0°C, relative humidity ±5 %, and air velocity ±50 % of the mean value. In addition, the mean radiant temperature shall not be more than 1.0°C different from the mean air temperature. Verify the spatial uniformity at least annually or after any significant modifications are made to the chamber. Verify spatial uniformity by recording values for the conditions stated above at 0.6 m (the midline elevation of the manikin on the cot) and 1.1 m above the floor at the location occupied by the manikin. Use sensing devices specified below when measuring the environmental conditions.

6.4.2 *Temporal Variations*—Do not exceed the following: air temperature ±0.5°C, mean radiant temperature ±0.5°C, relative humidity ±5 %, air velocity ±20 % of the mean value for data averaged over 5 min (see 6.4.5).

6.4.3 *Relative Humidity Measuring Equipment*—Any humidity sensing device with an accuracy of ±5 % relative humidity and a repeatability of ±3 % is acceptable (for example, wet bulb/dry bulb, dew point hygrometer). Only one location needs to be monitored during a test to ensure that the temporal uniformity requirements are met.

[3] Information on laboratories with heated manikins can be obtained from the Institute for Environmental Research, Kansas State University, Manhattan, KS 66506.