Designation: ~~F1720 – 14~~ F1720 – 17

An American National Standard

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

This standard is issued under the fixed designation F1720; 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

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, can be used to characterize sleeping bags and sleeping bag systems. Insulation values for sleeping bag systems can be used in body heat loss models to predict the temperature ratings for comfort.

1. Scope

1.1 This test method covers determination of the insulation value of a sleeping bag or sleeping bag system. 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 or sleeping bag system, 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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]

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

2.2 *ISO Standards:*[3]

~~ISO 13537 2002 Requirements for Sleeping Bags~~

ISO 15831 2004 Clothing—Physiological Effects—Measurement of Thermal Insulation by Means of a Thermal Manikin

ISO 23537-1 2016 Requirements for Sleeping Bags – Part 1: Thermal and Dimensional Requirements

[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.22 on Camping Softgoods.

Current edition approved ~~Nov. 1, 2014~~Sept. 1, 2017. Published ~~November 2014~~September 2017. Originally approved in 1996. Last previous edition approved in ~~2011~~2014 as ~~F1720 – 06 (2011).~~F1720 – 14. DOI: ~~10.1520/F1720-14.~~10.1520/F1720-17.

[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.

3. Terminology

3.1 *Definitions:*

3.1.1 *auxiliary products, n*—items used with a sleeping bag to create a sleeping bag system such as clothing, camp pillow, ground pad, and bivy sack.

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

3.1.2.1 *Discussion*—

~~A heavy men's business suit provides 1 clo of insulation.~~ The value of 1 clo was selected as roughly the insulation value of a heavy men's business suit, which should keep a resting man (producing heat at the rate of 58 W/m^2) comfortable in an environment at 21°C, air movement 0.1 m/s.

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

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

3.1.5 *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).

3.1.6 *sleeping bag system, n*—sleeping bag used with auxiliary products such as clothing, ground pad, and bivy sack.

3.1.7 *thermal insulation, n*—resistance to dry heat transfer by way of conduction, convection, and radiation.

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

3.1.8.1 *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 heated manikin is placed inside a sleeping bag or sleeping bag system in a cold environmental chamber.

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

4.3 The total thermal insulation of the sleeping bag or sleeping bag system (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 or sleeping bag systems. It can be used for material and design evaluations.

5.2 The measurement of the insulation provided by clothing (see Test Method F1291~~)~~, ISO 15831) and sleeping bags (ISO 23537) 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~~ It is feasible that departures from the instructions in this test method ~~may~~will 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~~ need to be reported with the results.

6. Apparatus

6.1 *Manikin*[4]—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 a ~~constant average surface temperature of 35°C. The manikin's height should be between 1.5 and 1.9 m with a surface area between 1.5 and 2.1 m~~constant, average surface temperature.~~[2].~~

6.1.1 *Size and Shape*—Construct the manikin to simulate the body of a human being, that is, ~~construct~~with 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~~170 ± 10 cm. Any departures from this description ~~should~~ need to 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 either 34 or 35°C. Do not

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

allow local deviations from the mean skin temperature to exceed ±0.3°C. 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~~ needs to 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 ~~metres)~~meters) are preferred over instantaneous devices (watt ~~metres).~~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, this standard does not provide specific calibration procedures. Develop and document an appropriate power calibration procedure.

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

6.3.1 *Point Sensors*—Point sensors ~~may~~shall be thermocouples, resistance temperature devices (RTDs), thermistors, or equivalent sensors. Ensure that they are no more than ~~3-mm~~ 2 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~~ Area-weight each sensor temperature when calculating the mean skin temperature for the body. ~~A~~ If point sensors are used, a minimum of 11 point sensors are required. ~~It is recommended that a sensor~~ At least one sensor shall be placed on the head, chest, back, arms, legs, hands, and feet. These sensors must be placed in the same position for each test, and the placement of the sensors shall be given in the report.

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~~ need to be area-weighted when calculating the mean ~~skin~~ surface (skin) temperature. Distributed sensors must be ~~small in diameter (that is,~~ less than 1 ~~mm)~~ mm in diameter and firmly ~~bonded~~attached to the manikin surface at all points.

6.4 *Controlled Environmental Chamber*—Place the manikin in a chamber at least 3 by 2 by 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 %, and 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.

6.4.4 *Air Temperature Sensors*—Shielded air temperature sensors shall be used. Any sensor with an overall accuracy of ±0.15°C is acceptable (for example, RTD, thermocouple, thermistor). The sensor shall have a time constant not exceeding 1 min. The sensor(s) shall be located at the midline elevation of the manikin (0.6 m from the floor), at least 0.4 m from the manikin. ~~A single sensor may be used,~~ It is acceptable to use a single sensor, but multiple sensors are preferred. If a single sensor is used, it shall be located midway between the head and the feet. If multiple sensors are used, they shall be spaced equally from the head to the feet and their readings averaged.

6.4.5 *Air Velocity Indicator*—Use an omnidirectional anemometer with ±0.05 m/s accuracy. Average the measurements for at least 1 min at each location. If it is demonstrated that velocity does not vary temporally by more than ±0.05 m/s, then it is not necessary to monitor air velocity during a test. The value of the mean air velocity must be reported, however. If air velocity is monitored, then measurement location requirements are the same as for temperature.

7. Sampling

7.1 It is desirable to test three identical sleeping bags so that sample variability will be reflected in the test results. Sample variance generally is larger for sleeping bags as compared with clothing. If only one sample is available, which is often the case with prototypes, replicate measurements can be made on one sleeping bag.

8. Preparation of Sleeping Bags

8.1 The sleeping bag ~~should~~shall be the appropriate size for the manikin with respect to its width and length. A bag that fits tightly and causes compression in the head, feet, or hip areas may have a lower insulation value than one that does not cause compression.