Testing Services for the Evaluation of

Fabric Systems, Clothing Systems, Sleeping Bag Systems,

Bedding Systems, and Personal Cooling Systems (PCS)

Kansas State University

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Kansas State University Schedule of Charges
Institute for Environmental Research
Effective May 14, 2019

Description of Services	External Cost Rate ($)
1. Dry hot plate test for measuring the insulation value of materials (ASTM D1518, ASTM F1868, ISO 11092) Unit of measure: 1 test result (average of 3 replications)	377
2. Sweating hot plate test for measuring the evaporative resistance of materials (ASTM F1868, ISO 11092) Unit of measure: 1 test result (average of 3 replications)	376
3. Hot plate tests for measuring the NFPA total heat loss value of materials (ASTM F1868) *Note: This is a combination of tests #1 and #2.* Unit of measure: 1 test result (average of 3 replications for each hot plate test and additional calculations)	751
4. Dry manikin test for measuring the insulation value of sleeping bags (ASTM F1720, EN 13537, ISO 23537) or bedding systems and determining the temperature rating for comfort Unit of measure: 1 test result (average of 3 replications)	600
5. Dry manikin test for measuring the insulation value of clothing (ASTM F1291, ISO 15831) and determining the temperature rating for comfort (ASTM F2732, ANSI ISEA 201) Unit of measure: 1 test result (average of 3 replications) and temperature ratings, if applicable	600
6. Sweating manikin test for measuring the evaporative resistance of clothing (ASTM F2370) Unit of measure: 1 test result (average of 3 replications)	812
7. Sweating manikin test for measuring the cooling effectiveness of personal cooling systems (ASTM F2371) Unit of measure: 1 test result (baseline test and PCS test; average of 2 replications)	1518

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8. Large environmental chamber (#8) (per day)	429.00
9. Small environmental chamber (#3 – #7) (per day)	319.00
10. Senior researcher (per hour)	174.62
11. Research technician (per hour)	64.66
12. Graduate research assistant (per hour)	38.67
13. Computational Analysis Work (per hour)	119.87
14. Computational Analysis Work – Graduate Student (per hour)	60.44

Important Notes:

- *A detailed description of each test follows.*
- *Prices include direct cost and indirect costs for the university (50%).*
- *Products are tested in the order that they are received at IER.*
- *If companies want work done in a rush (requiring work at night and on weekends), or if special protocols are needed for testing that require moving and modifying equipment, extra charges for labor will be applied.*
- *Companies are responsible for paying the shipping costs for returning the products via Federal Express, UPS, or DHL.*
- *On hot plate tests #1-3 and manikin tests #5-6: If a company sends only one product for testing, the client may be charged an additional 1/3 of the price for one replication of the bare plate test or nude manikin test. These data on the air layer resistance are required for determining the intrinsic values for the products. If more products are sent, IER will absorb the cost of these bare/nude tests.*

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Fabric Systems: Thermal Insulation

Property: Resistance to dry heat transfer (i.e., fabric insulation value)

Methods: ASTM D 1518 "Thermal Resistance of Batting Systems Using a Hot Plate"

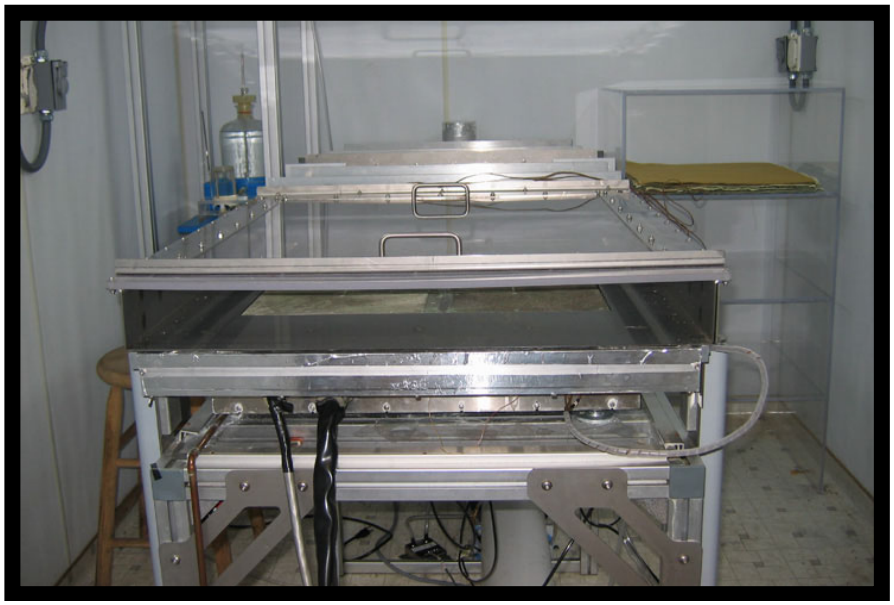
ASTM F 1868 “Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate Test” (Procedure Part A)

ISO 11092 "Textiles--Determination of Physiological Properties--Measurement of Thermal and Water-Vapour Resistance"

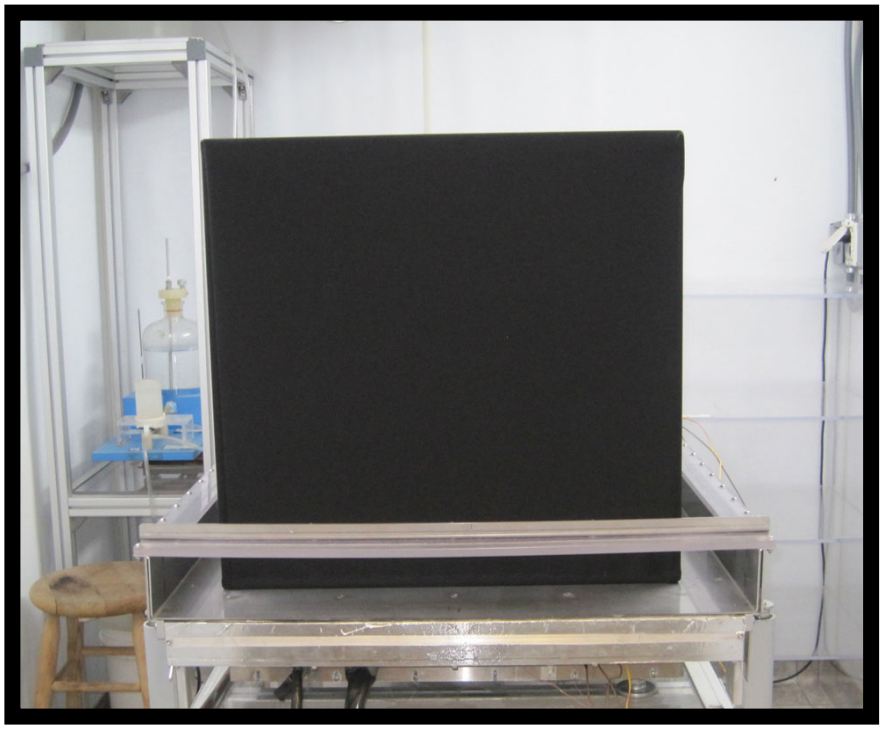
Instrument: Guarded hot plate in an environmental chamber; custom hoods provide either still air conditions, horizontal air flow, or vertical air flow at different levels

Specimen number and size: 3 20 x 20 inch squares

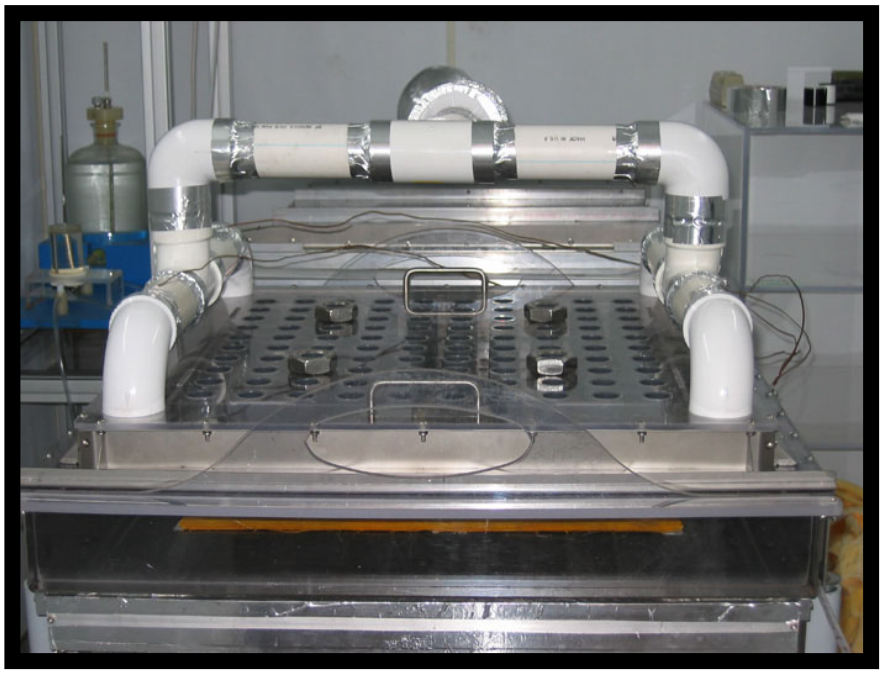
Cost: $377 per fabric type (3 reps)



Horizontal air flow hood over plate



Box hood (still air conditions)



Vertical air flow hood over plate

Fabric Systems: Evaporative Resistance

Property: Resistance to evaporative heat transfer

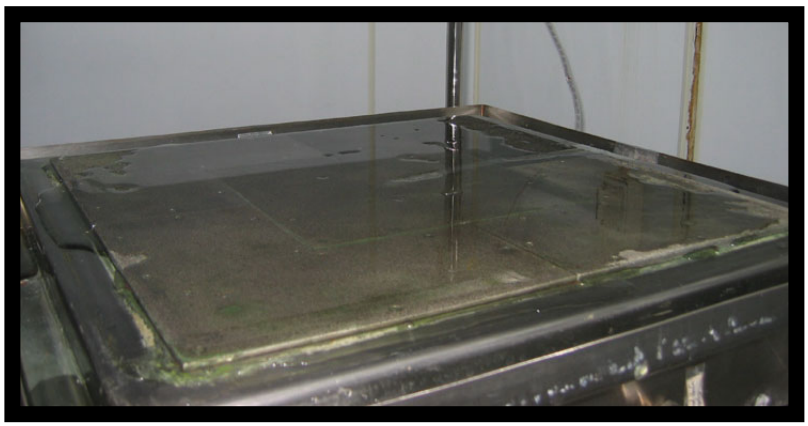
Methods: ASTM F 1868 “Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate Test” (Procedure Part B)

ISO 11092 "Textiles--Determination of Physiological Properties--Measurement of Thermal and Water-Vapour Resistance"

Instrument: Sweating hot plate in an environmental chamber; custom hoods provide either horizontal or vertical air flow at different levels

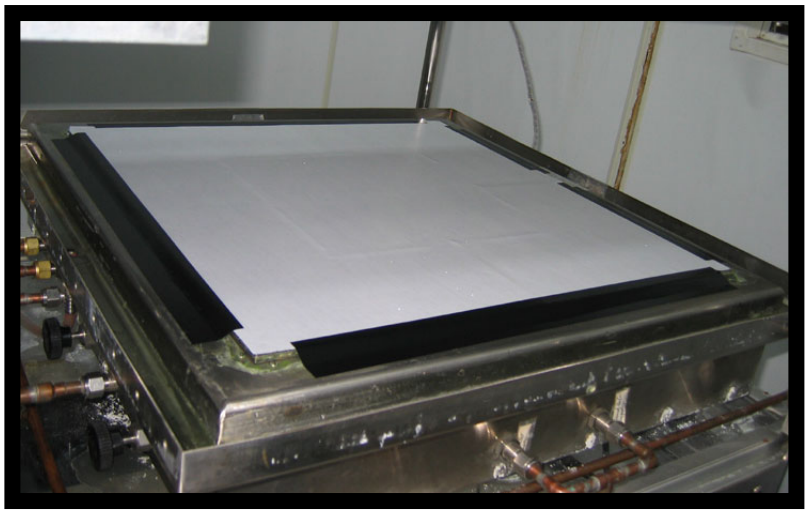
Specimen number and size: 3 20 x 20 inch squares

Cost: $376 per fabric type (3 reps)



Flooding the plate.

See photos of plate and hoods on previous page.



Water is covered with a PTFE liquid barrier to keep the fabric sample dry during the evaporative resistance test.

Fabric Systems: NFPA Total Heat Loss Test

Property: Total heat loss (from fire fighter fabrics)

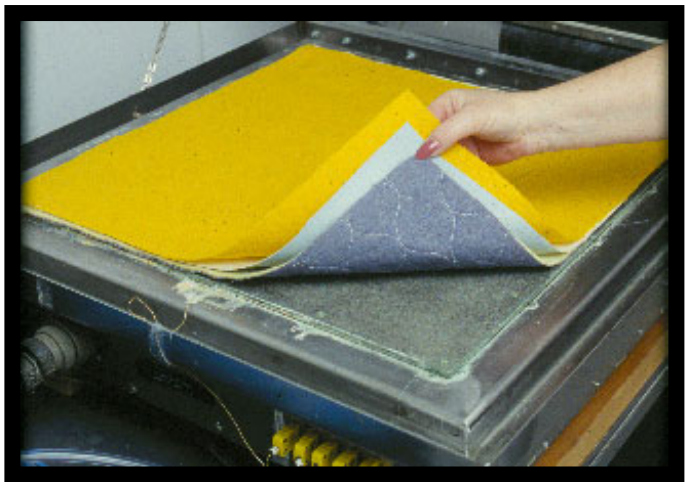
Method: ASTM F 1868 “Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate Test” (Procedure Part C)

THL Specification criteria are given in: NFPA 1951, NFPA 1971, NFPA 1977, NFPA 1992, NFPA 1994, NFPA 1999

Instrument: Sweating hot plate in an environmental chamber; custom hoods provide either horizontal or vertical air flow at different levels

Specimen number and size: 3 20 x 20 inch squares

Cost: $751 per fabric or fabric assembly (3 reps dry, 3 reps sweating)



Fire fighter turnout gear materials.

See other photos of the plate and air flow hoods on the previous two pages.

Cold Weather Clothing for Adults:
Thermal Insulation and Temperature Ratings

Property: Resistance to dry heat transfer (insulation value) provided by cold weather clothing systems

Method: ASTM F 2732 “Standard Practice for Determining the Temperature Ratings of Cold Weather Clothing”

Instrument: Thermal manikin in an environmental chamber

Specimen number and size: 1 set of garments sized to fit the manikin

Cost: $600 for 3 replications on one set of garments

Temperature Ratings: Heat transfer models are used with the insulation value to determine the temperature ratings for comfort at different activity levels. No additional charge for these calculations.

Cold Weather Clothing for Children:
Thermal Insulation and Temperature Ratings

Property: Resistance to dry heat transfer (insulation value) provided by cold weather clothing systems

Method: ASTM F 1291 "Standard Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin" *modified using child-size manikin*

Instrument: Child thermal manikin (boy's size 8) in an environmental chamber

Specimen number and size: 1 set of garments sized to fit the manikin

Cost: $600 for 3 replications on one set of garments

Temperature Ratings: Heat transfer models based on children's physiology at different ages are used with the insulation value to determine the temperature ratings for comfort at different activity levels. No additional charge for these calculations.

Clothing Systems: Thermal Insulation

Property: Resistance to dry heat transfer (insulation value) provided by clothing systems

Methods: ASTM F 1291 "Standard Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin"

ISO 15831 “Clothing – Physiological Effects – Measurement of Thermal Insulation by Means of a Thermal Manikin”

Instrument: Adult or child thermal manikin in an environmental chamber

Specimen number and size: 1 set of garments sized to fit the manikin

Cost: $600 for 3 replications on one set of garments

Note: Children’s clothing ensembles can be tested using these methods and our child-size manikin, Sonny. He is a boy’s size 8.

Clothing Systems: Evaporative Resistance

Property: Resistance to evaporative heat transfer provided by clothing systems

Method: ASTM F 2370 “Measuring the Evaporative Resistance of Clothing Using a Sweating Manikin”

Instrument: Sweating thermal manikin in an environmental chamber

Specimen number and size: 1 set of garments sized to fit the manikin

Cost: $812 for 3 independent replications

Personal Cooling Systems (PCS): Cooling Effectiveness and Duration

Property: Average cooling rate and duration of cooling provided by personal cooling systems (PCS) worn with protective clothing

Method: ASTM F 2371 "Standard Test Method for Measuring the Heat Removal Rate of Personal Cooling Systems Using a Sweating Heated Manikin"

Instrument: Sweating thermal manikin in an environmental chamber

Specimen number and size: 1 personal cooling system; garments for the base ensemble

Cost: $1,518 per system (baseline sweating test with the PCS off followed by a 2-hour test with the PCS on – 2 reps, a third rep if necessary)

Footwear: Thermal Insulation

Property: Resistance to dry heat transfer (insulation value) provided by footwear systems

Method: There is no standard method for evaluating footwear; the basic procedures in the whole body manikin standard ASTM F 1291 will be followed

Instrument: Thermal foot in an environmental chamber

Specimen number and size: 1 set of footwear sized to fit the left foot (10 1/2 shoe; 11 boot)

Cost: $600 for 3 replications on one shoe or boot

Note: We do not calculate temperature ratings for footwear for ethical reasons. The prediction models are based on heat loss from the whole body – not just the feet. Therefore, they are primarily affected by the clothing on the rest of the body.

Headwear: Thermal Insulation and/or Evaporative Resistance

Property: Resistance to dry heat transfer (insulation value) and/or the evaporative resistance provided by headwear and helmet systems

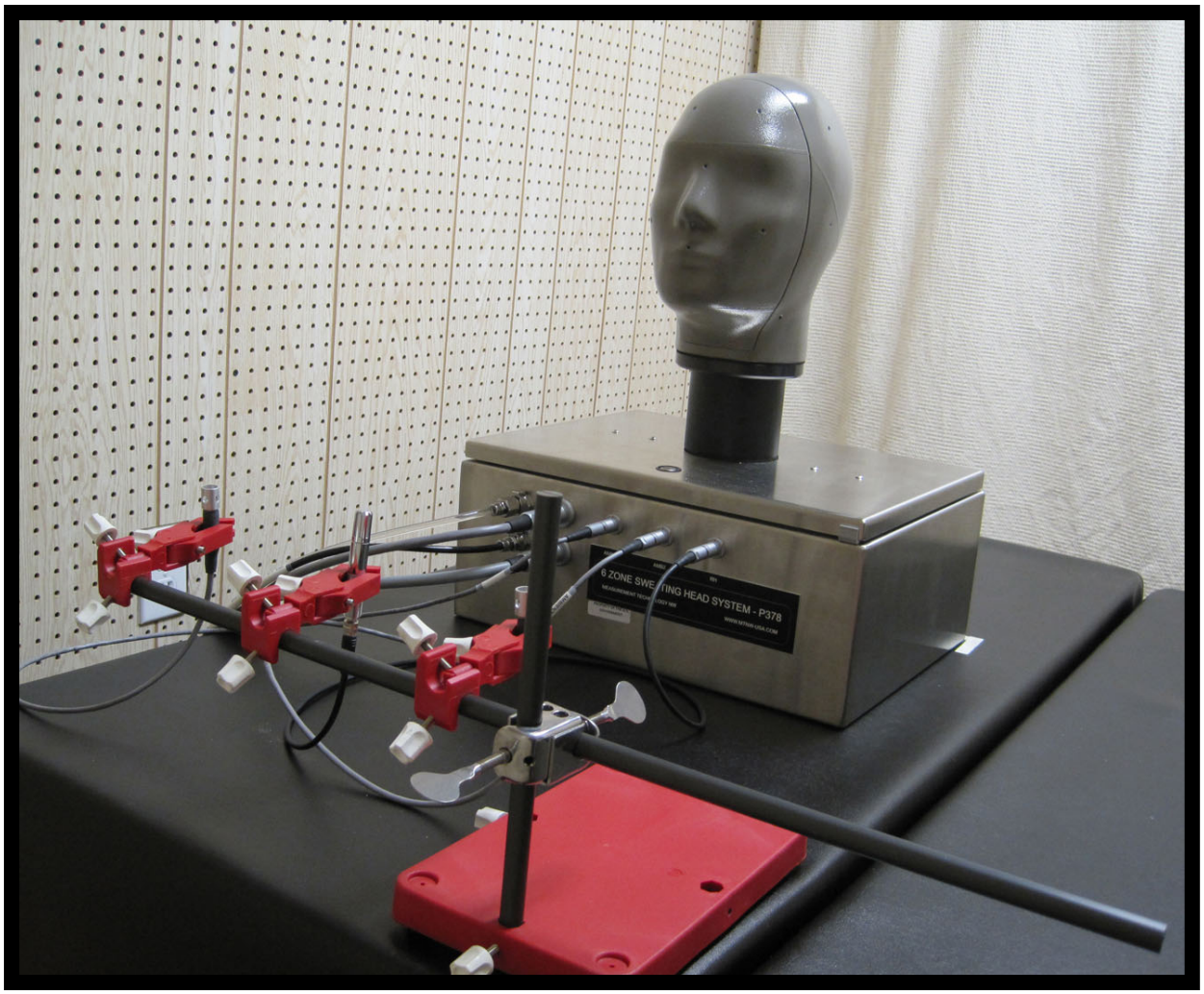
Method: There is no standard method for evaluating headwear; the basic procedures in the whole body manikin standards ASTM F 1291 and ASTM F 2370 will be followed

Instrument: Thermal sweating head in an environmental chamber

Specimen number and size: 1 set of garments sized to fit the head

Cost for insulation tests: $600 for 3 replications on one hat or helmet

Cost for evaporative resistance tests: $812 for 3 replications on one hat or helmet



Sleeping Bag Systems for Adults:
Thermal Insulation and Temperature Ratings

Property: Resistance to dry heat transfer (insulation value) provided by sleeping bags or sleeping bag systems

Methods: ISO 23537 “Part 1: Thermal and Dimensional Requirements” (replaced EN 13537 “Requirements for Sleeping Bags” in 2017)

ASTM F 1720 "Standard Test Method for Measuring the Thermal Insulation of Sleeping Bags Using a Heated Manikin"
We also test according to **military specifications**.

Instrument: Thermal manikin on a cot in environmental chamber; for the ISO method, the bag is tested on a board with standard thermal underwear and socks, a face mask, and a 1 ½ in. self-inflating pad

Specimen number and size: 1 regular or long sleeping bag (auxiliary products like clothing, ground pad, etc. may be tested as part of a bag system; IER has these, or a company may provide them)

Cost: $600 for 3 replications

Temperature Ratings: The comfort, limit, and extreme temperatures will be determined using the heat loss models in the ISO standard; KSU models can also be used with the ASTM standard; no additional charge for these calculations.

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ISO 23537 standard test (posture #1).

Optional ISO 23537 maximum comfort temperature test (posture #2).
Note: This requires a second manikin test.

Sleeping Bag Systems for Children:
Thermal Insulation and Temperature Ratings

Property: Resistance to dry heat transfer (insulation value) provided by sleeping bags or sleeping bag systems

Method: ASTM F 1720 "Standard Test Method for Measuring the Thermal Insulation of Sleeping Bags Using a Heated Manikin" *modified using child-size manikin*

Instrument: Child thermal manikin (boy's size 8) on a cot in an environmental chamber

Specimen number and size: 1 child-size sleeping bag (auxiliary products like clothing, ground pad, etc. may be tested as part of a bag system; IER has these, or a company may provide them)

Cost: $600 for 3 replications

Temperature Ratings: Heat transfer models based on children's physiology at different ages are used with the insulation value to determine the temperature ratings for comfort during sleep. No additional charge for these calculations.

Sleeping Bags: Loft

Property: Sleeping bag loft

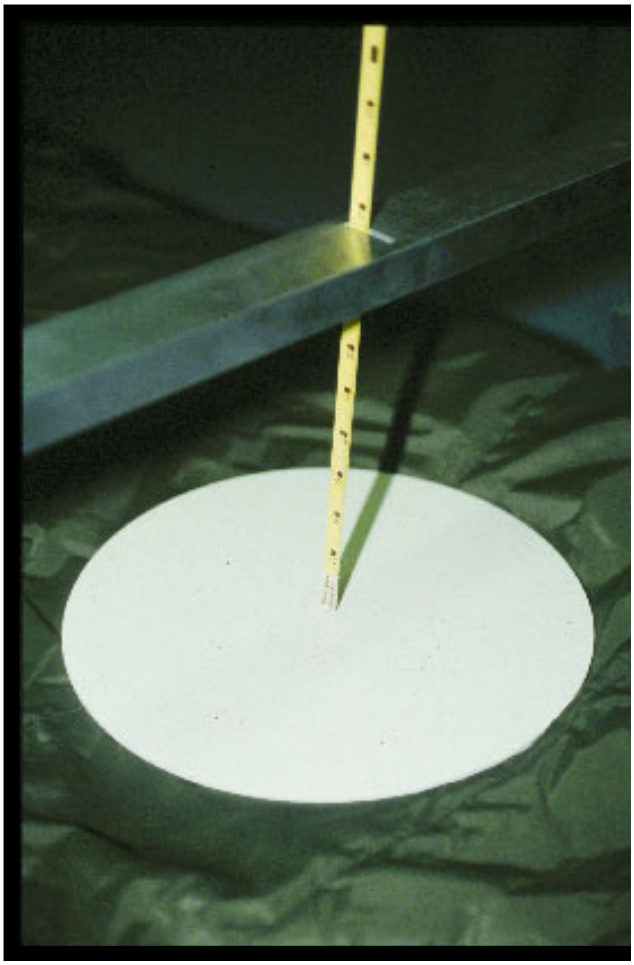
Method: ASTM F 1932 “Test Method for Measuring Sleeping Bag Loft”

Instrument: Loft tester

Specimen number and size: 1 or 3 sleeping bags

Cost: $64.66 per hour for research technician labor (3 replications of the test)

Note: We will only measure loft if the bags are already at the lab for manikin testing.



Sleeping Bags: Packing Volume

Property: Sleeping bag packing volume

Method: ASTM F 1853 “Test Method for Measuring Sleeping Bag Packing Volume”

Instrument: Plastic cylinder, a piston disk, weight on pulley system

Specimen number and size: 1 or 3 sleeping bags

Cost: $64.66 per hour for research technician labor (3 replications of the test)

Note: We will only measure packing volume if the bags are already at the lab for manikin testing.

250 pounds is applied evenly with a piston disk.

Bedding Systems: Thermal Insulation and Temperature Ratings

Property: Resistance to dry heat transfer (insulation value) provided by bedding systems

Methods: ASTM F 1720 "Standard Test Method for Measuring the Thermal Insulation of Sleeping Bags Using a Heated Manikin" Option #2 *modified by placing the manikin on a bed*

ASTM F 1291 "Standard Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin" *modified by placing the manikin on a bed*

Instrument: Thermal manikin on a mattress in environmental chamber

Specimen number and size: 1 set of bedding (comforters, blankets, etc.)

Cost for insulation tests: $600 for 3 replications on one bedding system

Temperature Ratings: Heat transfer models are used with the insulation value to determine the temperature for comfort during sleep; no additional charge for these calculations

Note: We can also evaluate the thermal and evaporative properties of mattresses. Call the Testing Coordinator to discuss possible test protocols.

Human Subject Testing

The physiological and subjective responses of human subjects wearing protective clothing, personal cooling systems (PCS), or sleeping bags can be measured under controlled conditions in environmental chambers.

Physiological Responses:

A. mean skin temperature (3-8 skin thermocouples)
B. body core temperature (ingestible temperature sensors to swallow)
C. heart rate (Polar™ S180i heart rate strap with electronic download of data into a computer)
D. sweat rate (weigh subject and clothing before and after experiment)
E. oxygen consumption and metabolic rate (metabolic cart)

Subjective Responses:

A. Thermal sensation scale (ASHRAE)
B. Borg perceived exertion scale
C. Clothing comfort, acceptability scales

Methods: ASTM F 2300 “Standard Test Method for Measuring the Performance of Personal Cooling Systems Using Physiological Testing”

ASTM F 2668 “Standard Practice for Determining the Physiological Responses of the Wearer to Protective Clothing Ensembles”

ISO 9886 “Ergonomics – Evaluation of Thermal Strain by Physiological Measurements”

ISO 8996 “Ergonomics of the Thermal Environment – Determination of Metabolic Rate”

Cost: Proposals are written on a case–by-case basis.

See photo on next page.