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Requirements for sleeping bags

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National foreword

This British Standard is the UK implementation of EN 13537:2012. It supersedes BS EN 13537:2002, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SW/136/11, Sleeping bags and tents.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Requirements for sleeping bags

Exigences pour les sacs de couchage

Anforderungen an Schlafsäcke

This European Standard was approved by CEN on 27 April 2012.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 13537:2012) has been prepared by Technical Committee CEN/TC 136 “Sports, playground and other recreational facilities and equipment”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2012, and conflicting national standards shall be withdrawn at the latest by November 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13537:2002.

In comparison with EN 13537:2002, the following changes have been made:

a) the calibration of thermal manikins for the measurement of thermal insulation of a sleeping bag has been introduced following the results of an extensive round robin test between 6 laboratories using a reference set of sleeping bags. This has improved the precision and reproducibility of the test results;

b) the test procedure of the thermal resistance measurement of the sleeping bag with the thermal manikin has been specified in more detail, improving the reproducibility of the test results;

c) a pre-treatment has been introduced for the thermal property tests for the sleeping bag;

d) measurement of the inside dimensions of sleeping bags has been included. It was formally specified in EN 13538-1 which has been withdrawn;

e) the thickness and elastic recovery of the sleeping bag, as determined by EN 13538-2, has been deleted from the requirements;

f) the easiness of packaging of the sleeping bag, as determined by EN 13538-3, has been deleted from the requirements;

g) based on new research, the extreme temperature limits in Table 1 have been recalculated and amended.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard has been substantially revised. The objectives of the revision were to simplify the standard by deleting requirements and test methods which had not been proven to be sufficiently reproducible or which did not contribute to the safety and quality performance of sleeping bags. The revision was also conducted in order to improve the inter-laboratory variability and repeatability of the test method for determination of the thermal properties of a sleeping bag.

Since the last edition of this European Standard, products in the market have evolved to reflect the changing needs of the user. It was the intention of the committee during this revision that the standard would reflect these continuous and changing needs and not become restrictive in respect of future technology and advances in the manufacturing industry.

In buying a sleeping bag, the consumer expects (along with other aspects such as functional design, good fit, low weight and volume and durability), information regarding which temperature range the sleeping bag can be used. This temperature range serves to prevent the person in the bag feeling too cold on the one hand or too hot, combined with unpleasant sweating, on the other. The primary aim of this European Standard is to provide this information to the consumer by specifying a test procedure and an evaluation model to quantify the thermophysiological function of sleeping bags (see also Annex E).

An inter-laboratory test, involving six different laboratories, was organised within the present CEN working group on a set of six sleeping bags filled with feathers and downs and synthetics. Six human shaped thermal manikins were used, consisting of 6 to 35 independent segments and corresponding to the requirements for testing protective clothing against cold.

The test showed the following conclusions:

— even with multi-sectional manikins, the design and especially the number of independent sections can influence the value of thermal resistance by up to 20 %;

— yet the test results of thermal resistance with all manikins showed a maximum difference of 10 % (leading e.g. to a difference in $T_{\mathbf{lim}}$ of 3,0 °C for a sleeping bag with $T_{\mathbf{lim}}$ = 0 °C);

— the weight of the manikin did not significantly effect the test results.

1 Scope

This European Standard specifies the requirements and test methods as well as provisions for labelling of adult sized sleeping bags for use in sports and leisure time activities.

This European Standard does not apply to sleeping bags intended for specific purpose such as military use and extreme climate zone expedition. It does not apply to sleeping bags for children or babies: no prediction model exists for the determination of the limiting temperatures based on the thermal resistance of the sleeping bag for these demographics. Moreover, such a model for testing cannot be developed because the necessary controlled sleep trials with children or babies in climatic chambers are, out of ethical reasons, not permitted.

This European Standard describes the method for the assessment of the performance in steady state conditions of a sleeping bag with regard to the protection against cold.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12130, *Feather and down — Test methods — Determination of the filling power (massic volume)*

EN 12132-1, *Feather and down — Methods of testing the down proof properties of fabrics — Part 1: Rubbing test*

EN 12934, *Feather and down — Composition labelling of processed feathers and down for use as sole filling material*

EN 12935, *Feather and down — Hygiene and cleanliness requirements*

EN 13088, *Manufactured articles filled with feather and down — Method for the determination of a filled product's total mass and of the mass of the filling*

EN 13538-3, *Determination of dimensional characteristics of sleeping bags — Part 3: Volume under load and easiness of packing*

EN 15586, *Textiles — Methods of testing the fibre proof properties of fabrics: Rubbing test*

EN 29073-1, *Textiles — Test methods for nonwovens — Part 1: Determination of mass per unit area*

EN ISO 105-B02, *Textiles — Tests for colour fastness — Part B02: Colour fastness to artificial light: Xenon arc fading lamp test (ISO 105-B02)*

EN ISO 105-C06, *Textiles — Tests for colour fastness — Part C06: Colour fastness to domestic and commercial laundering (ISO 105-C06)*

EN ISO 105-E04, *Textiles — Tests for colour fastness — Part E04: Colour fastness to perspiration (ISO 105-E04)*

EN ISO 105-X12, *Textiles — Tests for colour fastness — Part X12: Colour fastness to rubbing (ISO 105-X12)*

EN ISO 139, *Textiles — Standard atmospheres for conditioning and testing (ISO 139)*

EN ISO 3758, *Textiles — Care labelling code using symbols (ISO 3758)*

EN ISO 12947-1, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 1: Martindale abrasion testing apparatus (ISO 12947-1)*

EN ISO 12947-2, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 2: Determination of specimen breakdown (ISO 12947-2)*

EN ISO 13937-1, *Textiles — Tear properties of fabrics — Part 1: Determination of tear force using ballistic pendulum method (Elmendorf) (ISO 13937-1)*

EN ISO 15831, *Clothing — Physiological effects — Measurement of thermal insulation by means of a thermal manikin (ISO 15831)*

ISO 11092, *Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
manufacturer
organization responsible for designing and manufacturing a sleeping bag covered by this European Standard

3.2
comfort temperature (T_{comf})
lower limit of the comfort range, down to which a sleeping bag user with a relaxed posture, such as lying on their back, is globally in thermal equilibrium and just not feeling cold

Note 1 to entry: For more information see C.7.3.

3.3
limit temperature (T_{lim})
lower limit at which a sleeping bag user with a curled up body posture is globally in thermal equilibrium and just not feeling cold

Note 1 to entry: For more information see C.7.2.

3.4
extreme temperature (T_{ext})
lower extreme temperature where the risk of health damage by hypothermia occurs

Note 1 to entry: For more information, see C.7.1.

Note 2 to entry: This is a point of danger which can lead to death.

3.5
maximum temperature (T_{max})
upper limit of comfort range, up to which a partially uncovered sleeping bag user just does not perspire too much

Note 1 to entry: For more information see C.7.4.

3.6
thermal manikin
dummy with human shape and heated body surface which allows the determination of thermal transfer through the sleeping bag under steady-state conditions (i.e. constant heat flux and temperature gradient between body surface and ambient air)

3.7
thermal resistance (R_c)
thermal insulation
property of the sleeping bag which is related to the dry heat loss of the sleeping bag user (a combination of conductive, convective and radiative heat transfer), effected by the difference of temperature between the skin and the ambient air, as measured with a thermal manikin

Note 1 to entry: This thermal resistance represents the insulative property of a sleeping bag, which includes the effects of the shell fabrics and filling materials, air volume in the cavity inside the sleeping bag, boundary air layer on the outer face of the sleeping bag, mattress underneath the sleeping bag and garments worn by the sleeping bag user.

4 Requirements and test methods

4.1 General

For test procedures that refer to EN ISO 139, the default conditions of 20 °C and 65 % relative humidity shall be used.

4.2 Fabrics

4.2.1 Down proofness

When testing the fabric/fabric combinations of the shell or lining of the sleeping bag in accordance with EN 12132-1, the number of feather and/or down particles counted as required in EN 12132-1 shall not exceed ten for each fabric/fabric combination.

4.2.2 Synthetic fibre proofness

When tested in accordance with EN 15586, the number of synthetic fibres protruded through the fabric of the sleeping bags shall not exceed 30 for each cushion.

4.2.3 Mechanical properties

4.2.3.1 Abrasion

When tested in accordance with EN ISO 12947-1 and EN ISO 12947-2, the fabrics for sleeping bags shall withstand at least 20 000 test cycles.

4.2.3.2 Tear strength

When tested in accordance with EN ISO 13937-1, the tear strength of lining and shell fabrics shall be a minimum of 10 N.

4.2.3.3 Colour fastness

a) When testing the colour fastness to rubbing according to EN ISO 105-X12 wet and dry, the requirement for staining shall be a minimum of 3-4.

b) When testing the colour fastness to washing according to EN ISO 105-C06 at care label temperature, the requirements for staining and change of colour shall be a minimum of 4.

c) When testing the colour fastness to perspiration according to EN ISO 105-E04, the requirement for staining and change of colour shall be a minimum of 3-4.

d) When testing the colour fastness to light according to EN ISO 105-B02, the requirement for change of colour shall be a minimum of 4-5.

4.3 Filling material

4.3.1 Feather and/or down

4.3.1.1 Composition

The composition of the filling material shall be determined in accordance with EN 12934.

4.3.1.2 Hygienic state

The filling material shall conform to the requirements according to EN 12935.

4.3.1.3 Filling power

The filling power shall be tested in accordance with EN 12130.

The filling power shall not deviate by more than ± 5 % from the declared nominal value.

4.3.1.4 Filling material mass

The filling material mass, in g, shall be measured according to EN 13088.

The filling material mass shall not deviate by more than ± 7 % from the declared nominal value.

4.3.2 Filling material other than feather and/or down

4.3.2.1 Mass per unit area

The mass per unit area, in g/m², shall be measured according to EN 29073-1.

The mass per unit area shall not deviate by more than ± 7 % from the declared nominal value.

4.4 Finished articles

4.4.1 Water vapour permeability index

When tested in accordance with ISO 11092, the material specific water vapour permeability index (i_{mt}) of the sleeping bag shall be a minimum of 0,45. Where front and back area of the sleeping bag are of different material combinations, both parts shall be tested.

4.4.2 Inside dimensions

4.4.2.1 Inside length

To enable labelling of the sleeping bag, the inside length of the sleeping bag shall be measured within ± 3 cm. The measurement is made by turning the sleeping bag inside out and measuring the length from the position of the seam where the heel of the foot is placed to the top of the sleeping bag (excluding any vertical components of the hood), without applying any force to extend the sleeping bag length.

4.4.2.2 Maximum inside width

To enable labelling of the sleeping bag, the maximum inside width shall be measured within ± 2 cm. The measurement is made by turning the sleeping bag inside out and measuring the circumference at the widest point without stretching the fabric. If the maximum inside width of the sleeping bag is not in the chest area, then the position of the widest point of the sleeping bag shall be indicated on the label. The circumference is halved to provide the width of the sleeping bag. If the sleeping bag has elastic seams, a force of (10 ± 1) N may be used to extend these seams prior to measurement, for instance by using a spring balance.

4.4.2.3 Inside foot width

To enable labelling of the sleeping bag, the foot width shall be measured within ± 2 cm. The measurement is made by turning the sleeping bag inside out and measuring the circumference at a distance (30 ± 1) cm towards the hood from the position where the heel of the foot is placed. The circumference is halved to provide the width of the sleeping bag. If the sleeping bag has elastic seams, a force of (10 ± 1) N may be used to extend these seams prior to measurement, for instance by using a spring balance.

4.4.3 Total mass

The total mass of sleeping bags filled with feather and/or down shall be determined in accordance with EN 13088.

For sleeping bags filled with materials other than feather and down, samples shall be conditioned according to EN ISO 139 and the mass of the sleeping bag (without stuff sack) shall be determined. The total mass shall not deviate by more than ± 7 % from the declared nominal value.

4.4.4 Volume under load

The volume of the sleeping bag shall be determined according to EN 13538-3.

The volume shall not deviate by more than ± 5 % from the declared nominal value.

4.4.5 Thermal properties

4.4.5.1 Principle

The thermal resistance of the sleeping bag is measured with a thermal manikin which meets the requirements and test procedure of EN ISO 15831 and which is inserted into the sleeping bag and placed in a controlled atmosphere.

A physiological model is then applied which uses this thermal resistance to determine ambient temperatures corresponding to a range of utility of the sleeping bag.

4.4.5.2 Thermal resistance

4.4.5.2.1 Thermal resistance posture 1 ($R_c(1)$)

The thermal resistance posture 1 ($R_c(1)$) is measured with the manikin completely inserted into the sleeping bag and lying on its back. The bag's zippers, if any, are closed. The bag's hood, if present, covers the manikin's head, and the cords of the hood are tightened as much as possible without using any additional aids (e.g. clothes pins, etc.) not supplied with the sleeping bag.

For sleeping bags that have hood draw cords with which the hood aperture can be closed to less than 120 mm diameter or 375 mm perimeter, a cold protective mask[1)] shall be used on the manikin's face. For sleeping bags with hood draw cords with which the hood aperture cannot be closed to less than 120 mm diameter or 375 mm perimeter, a cold protective mask shall not be used on the manikin's face. For sleeping bags that do not have a hood or do not have hood draw cords, a cold protective mask shall not be used.

$R_c(1)$ is determined using either the serial or the parallel calculation method according to EN ISO 15831. A combination of these two calculation methods is also possible. With a given manikin, the decision as to which

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1) MIL-M-43294 C (Mask, extreme cold weather; olive green 207) and MK 5507 are the trade names of a product supplied by Colemans and Impuls. This Information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the products named. Equivalent products may be used if they can be shown to lead to the same results.

calculation model is appropriate shall be based on the results of the calibration procedure including the correlation for the individual thermal manikin, as described in 4.4.5.9.

4.4.5.2.2 Thermal resistance posture 2 ($R_c(2)$)

The thermal resistance posture 2 ($R_c(2)$) is measured with the manikin only partly inserted into the sleeping bag, and lying on its back. The upper part of the sleeping bag is pulled up only to the manikin's arm pits; and the arms of the manikin lie on top of the bag's upper part. The zippers of the sleeping bag, if any, are completely opened. The bag's hood, if present, is placed below the manikin's head without tightening the cords. No cold-protective mask is on the manikin's face.

$R_c(2)$ is determined using the parallel calculation method according to EN ISO 15831.

4.4.5.3 Thermal manikin

Specifications of existing thermal manikins vary widely, and they all imply somewhat specific operation conditions. Therefore, in this European Standard, the requirements on the manikin and operation conditions are left open as far as possible, and a calibration procedure (see 4.4.5.9) shall be carried out in order to achieve comparability of the test results of different test houses.

The manikin shall fulfil the following requirements:

— body height between 1,5 m and 1,9 m with a surface area between 1,5 m^2 and 2,1 m^2;

— internal heating with controlled and measurable heat flux (either single global internal heater, single global surface heater or different independent surface heaters);

— at least one temperature measurement of the manikin (either global internal temperature or mean surface temperature);

— regulation to a constant value of either heat flux or surface temperatures so that the measurement can be operated in steady-state condition.

During the test, the manikin shall be dressed with the following garments:

— two-piece suit (upper part with long sleeves, trousers) with a material specific thermal resistance R_{ct} = (0,040 m² K/W to 0,060 m² K/W) tested in accordance with ISO 11092;

— knee-length socks with a material specific thermal resistance R_{ct} = (0,040 m² K/W to 0,060 m² K/W) tested in accordance with ISO 11092.

4.4.5.4 Artificial ground

The test shall be operated with the manikin lying on a mattress with a material specific thermal resistance (R_{ct}) of 0,85 m^2 K/W ± 7 % when tested in accordance with ISO 11092 and placed on an artificial ground. This ground shall consist of a rigid support (e.g. a wooden board large enough that no part of the manikin or the sleeping bag protrudes over the board) with a thickness of 12 mm to 30 mm.

The artificial ground is held above the floor by some kind of support which allows air circulation underneath the artificial ground.

4.4.5.5 Climatic room

The test is operated in a climatic room in which the air temperature shall not fluctuate by more than ± 0,5 °C. The air temperature is set to a value which guarantees that the temperature gradient between the manikin's surface and air is larger than 15 K.

The difference between the air temperature and the radiative temperature of the walls shall be less than 2 K.

The air flow inside the climatic room shall be below 0,5 m/s (typically 0,3 m/s).

Relative humidity inside the climatic room can be at any value between 40 % and 80 %.

4.4.5.6 Test samples and pre-treatment

Before testing, the sleeping bag shall be dry tumbled in a dryer with a capacity of at least 250 l without any load for 15 min at a temperature of less than 30 °C. After this dry tumbling and immediately prior to the test, it shall be conditioned for at least 12 h in the ambient conditions of the test.

4.4.5.7 Test procedure

The test shall be carried out according to the minimum requirements in 4.4.5.3 to 4.4.5.5.

For each specific manikin, the position of the arms and legs in relation to the torso of the manikin, the wooden board and the artificial ground shall be defined as part of the calibration procedure and remain the same in all the tests performed according to this European Standard. Thus, operate the manikin either with constant heat flux, and measure the resulting temperature (surface or internal temperature), or operate the manikin with regulated constant temperature (surface or internal), and measure the resulting heat flux.

Choose the ambient climatic conditions of the test and set the values of either manikin surface or internal temperature or heat flux from the manikin's body so that the heat flux lies between 20 W/m^2 and 120 W/m^2 or so that its surface or internal temperature remains between 25 °C and 40 °C.

After steady-state thermal transfer is established, measure the manikin's heat loss, manikin surface or internal temperature and ambient air temperature. To ascertain a steady-state situation, it is recommended to wait for a mean value of the quantities above during a time period long enough to guarantee the reproducibility of the measurement as given in Annex B (a minimum of 20 min).

Calculate the value of the thermal resistance $R_c(1)$ and/or $R_c(2)$ by applying the correlation gained from the calibration procedure as given in 4.4.5.9.

At least three independent tests, starting with inserting the manikin into the sleeping bag, with either one or more specimen items shall be performed and the arithmetic mean value of the thermal resistance of the sleeping bag sample shall be calculated.

4.4.5.8 Calculation of temperatures of the range of utility

The sleeping bag's comfort, limit and extreme temperatures (T_{comf}, T_{lim}, T_{ext}) shall be determined on the basis of the thermal resistance posture 1 ($R_c(1)$), according to the physiological model described in Annex C. The sleeping bag's maximum temperature T_{max} can be determined optionally on the basis of the thermal resistance posture 2 ($R_c(2)$), according to the physiological model also described in Annex C.

The temperatures of the sleeping bag's range of utility can also be obtained with acceptable accuracy using Table 1 and Table 2. If the thermal resistances $R_c(1)$ and $R_c(2)$ measured for the sleeping bag are in between the values in Table 1 or Table 2, a linear interpolation shall be performed on the basis of the nearest upper and lower $R_c(1)$ or $R_c(2)$-values. The temperature limits to be given in the graph for the ranges of utility (see 6.1) are rounded to the nearest integral number.

Table 1 — Lower temperature limits of the range of utility

Thermal resistance Posture 1 $R_c(1)$ m² K/W	**Extreme Temperature** T_{ext} °C	**Limit Temperature** T_{lim} °C	**Comfort Temperature** T_{comf} °C
0,500	+ 5,0	+ 14,2	+ 17,2
0,540	+ 2,8	+ 12,7	+ 15,9
0,580	+ 0,6	+ 11,2	+ 14,6
0,620	–1,5	+ 9,7	+ 13,3
0,660	– 3,7	+ 8,1	+ 12,0
0,700	– 5,8	+ 6,6	+ 10,7
0,740	– 7,9	+ 5,1	+ 9,4
0,780	– 10,1	+ 3,6	+ 8,1
0,820	– 12,2	+ 2,2	+ 6,9
0,860	– 14,3	+ 0,7	+ 5,6
0,900	– 16,3	– 0,8	+ 4,3
0,940	– 18,4	– 2,3	+ 3,1
0,980	– 20,5	– 3,7	+ 1,8
1,020	– 22,5	– 5,2	+ 0,6
1,060	– 24,5	– 6,7	– 0,7
1,100	– 26,5	– 8,1	– 1,9
1,140	– 28,5	– 9,5	– 3,1
1,180	– 30,5	– 11,0	– 4,4
1,220	– 32,5	– 12,4	– 5,6
1,260	– 34,4	– 13,8	– 6,8
1,300	– 36,4	– 15,2	– 8,0
1,340	– 38,3	– 16,7	– 9,2
1,380	– 40,2	– 18,1	– 10,4
1,420	– 42,2	– 19,5	– 11,6
1,460	– 44,0	– 20,8	– 12,8
1,500	– 45,9	– 22,2	– 14,0
1,540	– 47,8	– 23,6	– 15,2

Table 2 — Upper temperature limit of the range of utility

Thermal resistance Posture 2 $R_c(2)$ m^2 K/W	**Maximum Temperature** T_{max} °C
0,200	+ 31,1
0,240	+ 29,6
0,280	+ 28,2
0,320	+ 26,7
0,360	+ 25,2
0,400	+ 23,8
0,440	+ 22,3
0,480	+ 20,9
0,520	+ 19,4
0,560	+ 18,0
0,600	+ 16,5
0,640	+ 15,1
0,680	+ 13,6
0,720	+ 12,2
0,760	+ 10,7
0,800	+ 9,3

4.4.5.9 Calibration of thermal manikin

In order to calibrate a specific thermal manikin and the related operating conditions, the measurement shall be performed on the reference set of sleeping bags[2)] whose thermal resistance $R_c(1)$ covers the range 0,700 m^2 K/W to 1,300 m^2 K/W.

A linear or exponential correlation shall be found between the thermal resistance figures issued from the measurement and the reference values for the thermal resistances $R_c(1)$ and $R_c(2)$ of the reference set of sleeping bags (see Table A.1).

NOTE These reference values have been obtained with the thermal manikin "Charlie 3"[3)] as described in Annex A.

The deviation of the corrected $R_c(1)$ and $R_c(2)$-values obtained by applying this linear or exponential correlation from the reference thermal resistance values of the reference set of sleeping bags shall fulfil the following requirements:

a) mean deviation with the complete set of the reference sleeping bags is less than 5 % (variation coefficient);

b) no individual deviation is more than 10 % (variation coefficient);

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2) The reference sets of sleeping bags are available from:
   a) SWEREA IVF AB, Box 104, SE- 431 22 Mölndal (Sweden);
   b) Hohenstein Laboratories GmbH & Co. KG, Schloss Hohenstein, D - 74357 Bönnigheim (Germany);
   c) AITEX, Plaza Emilio Sala 1, E - 03801 Alcoy (Alicante) (Spain).

This Information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the thermal manikin named.

3) Charlie 3 is the name of the thermal manikin of Hohenstein Laboratories GmbH & Co. KG. This Information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the thermal manikin named. Equivalent thermal manikins may be used if they can be shown to lead to the same results.

c) global bias (i.e. mean value) on the complete set of the reference sleeping bags does not exceed 5 % (variation coefficient).

Additionally, the repeatability of the measurement on each sleeping bag shall be better than 4 % (variation coefficient).

5 Test report

The test report shall include:

a) reference and description of the sleeping bag sample;

b) description of operating conditions, and especially:

   1) description of the thermal manikin, garments worn and artificial ground;

   2) ambient conditions in the climatic room (temperature, humidity, wind speed);

c) results of the test (thermal resistance $R_c(1)$ and/or $R_c(2)$ of the sleeping bag sample);

d) calculated temperatures of the range of utility of the sleeping bag sample T_{ext}, T_{lim}, T_{comf} and/or T_{max};

e) reference to this European Standard;

f) details of deviations from this European Standard, if applicable;

g) date of test.

6 Labelling

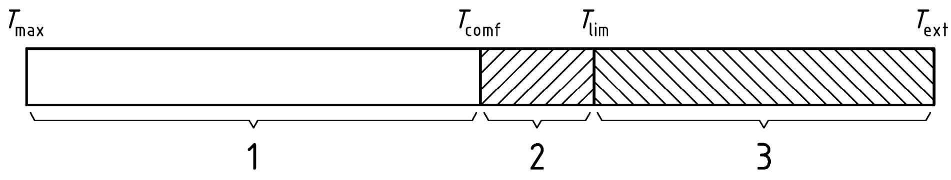
6.1 Graph for the range of utility

The range of utility for the sleeping bag sample shall be given on the label for marking (see 6.2) in the form of a graph.

The transition range shall be marked. The risk range shall also be marked and, simultaneously, the hazards existing in such environmental temperatures shall be pointed out. The comfort range may be marked.

The ranges shown in the graph shall be termed "comfort range", "transition range" and "risk range". These terms shall be given below the respective range. At the temperature limits T_{max}, T_{comf}, T_{lim}, and T_{ext} the respective values shall be given in °C.

The graph including its given data shall be used in a linear form. An example is shown in Figure 1. The colouring and the scale of the graph can be designed freely.



Key
1 comfort range
2 transition range
3 risk range

Figure 1 — Example for a graph for the range of utility

Below the graph, a warning note shall be included with the following wording:

"**WARNING: In the risk range a strong sensation of cold has to be expected. There is a risk of health damage by hypothermia.**"

For a warning of misuse of temperature rating, see Annex D.

6.2 Marking

The following information shall be permanently attached to the sleeping bag (e.g. by printing on the sleeping bag or by sewn-in labels):

a) reference to this European Standard and year of publication (EN 13537:2012);

b) composition of the filling, shell fabric and lining;

c) ranges of utility (graph);

d) care labelling, according to EN ISO 3758;

e) name of the manufacturer;

f) name or reference number of the product.

6.3 Information supplied to the consumer

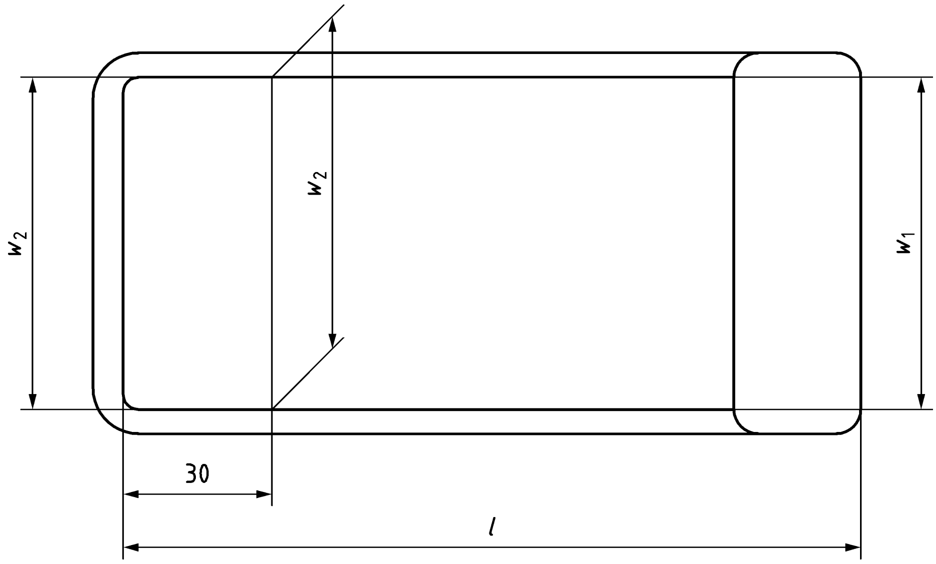
6.3.1 Mandatory information

The following information shall be supplied to the consumer by the manufacturer together with the sleeping bag at the point of sale:

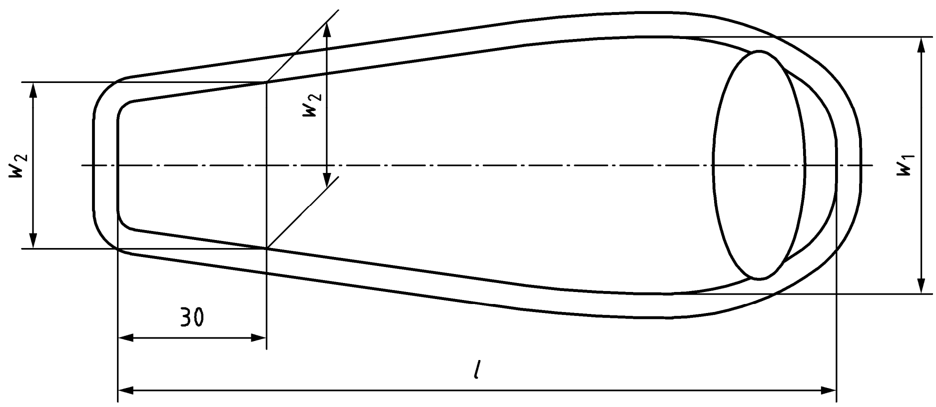
a) inside length, maximum inside width and foot width;

The inside length, maximum inside width and foot width in cm shall be given in a pictogram (for an example, see Figure 2).

Dimensions in centimetres



a) rectangular sleeping bag



b) mummy shaped sleeping bag

Key

l inside length

w_1 maximum inside width

w_2 inside foot width

Figure 2 — Pictograms

b) total mass of the sleeping bag, rounded to the nearest 50 g;

c) name and address of the manufacturer.

6.3.2 Optional information

The following information may be supplied to the consumer by the manufacturer together with the sleeping bag:

a) filling material mass;

b) filling power;

c) volume under load of the sleeping bag, rounded to the nearest 0,5 l.

Annex A
(normative)

Reference values of thermal resistance for calibration

A.1 General

The reference values for thermal resistances $R_c(1)$ and $R_c(2)$ are those obtained with the thermal manikin "Charlie 3"[3)] operated in the specific conditions described in this annex.

A.2 Thermal manikin

The thermal manikin "Charlie 3"[3)] has a human shape with trunk, head with hair, mobile arms and legs, hands and feet. Its dimensions correspond to German standard garment size 50/52. Its mass is 44 kg. When laid within a sleeping bag, the manikin has his left arm folded over the chest, and his right arm lying alongside the torso.

The body of the manikin is divided into 16 segments with independent surface temperature sensors and electric heating wires. The heating is monitored to maintain surface temperature of the corresponding segment at a constant value of (31 ± 0,1) °C; the surface of the manikin is made from a material of high thermal conductivity so as to guarantee uniformity of surface temperature. The power provided for heating is measured with an accuracy of ± 2 %.

A.3 Garments and artificial ground

The garments and artificial ground used in the test with "Charlie 3"[3)] are those specified in 4.4.5.3 and 4.4.5.4.

A.4 Operating conditions

Air temperature within the climatic room is (15 ± 0,1) °C, and air speed is (0,3 ± 0,1) m/s. The air flow direction is vertical.

Measurement is made when thermal steady-state conditions are obtained.The heat loss of each of the 16 segments of the manikin "Charlie 3"[3)] is then recorded. Thermal resistance posture 1 $R_c(1)$ of the sleeping bag is calculated according to the serial calculation method, as described in EN ISO 15831.

Thermal resistance posture 2 $R_c(2)$ of the sleeping bag is calculated according to the parallel calculation method according to EN ISO 15831.

A.5 Reference thermal resistances of the reference set of sleeping bags

The reference values of the thermal resistances of the reference set of sleeping bags are listed in Table A.1.

Table A.1 — Reference values of thermal resistance

Sleeping bag Sample	**Thermal resistance Posture 1** $R_c(1)$ m² K/W	**Thermal resistance Posture 2** $R_c(2)$ m² K/W
A	0,779	0,368
B	0,867	0,387
C	0,938	0,397
D	1,290	0,474
E	1,309	0,430
F	0,623	0,323

Annex B
(informative)

Precision of test results

B.1 Repeatability

In an inter-laboratory test involving six different thermal manikins and six different sleeping bags, for the thermal resistances $R_c(1)$ and $R_c(2)$, the precision with three repeated measurements on the same sleeping bag specimen, has been found to be 3,6 % (variation coefficient).

B.2 Reproducibility

An inter-laboratory test involving six different thermal manikins and six different sleeping bags has shown a reproducibility of the thermal resistances $R_c(1)$ and $R_c(2)$ of 5 % (variation coefficient).

Annex C
(informative)

Physiological model for calculation of range of utility

C.1 Thermal balance and calculation of temperatures of the range of utility

Temperatures of the range of utility are the ambient air temperatures which equilibrate thermal balance of the sleeping bag user:

$$M = H_c + H_e + H_{res} + \Delta S \qquad (C.1)$$

where

- M is the metabolic heat production of the sleeping bag user (detailed in C.2);
- H_c is the dry thermal loss through the sleeping bag and from uncovered areas of the body (detailed in C.3);
- H_e is the thermal loss due to evaporation of sweat on the skin surface (detailed in C.4);
- H_{res} is the respiratory thermal loss (detailed in C.5);
- ΔS is the change of body heat content of the sleeping bag user (detailed in C.6).

The calculation is performed through an iterative process on ambient temperature and mean skin temperature, until thermal equilibrium expressed by the Formula (C.1) is fulfilled.

The temperatures of the range of utility obtained depend on the consideration of physiological stress for the sleeping bag user (metabolic heat production, thermal debt, skin temperature and posture) which is detailed in C.7.

Ambience is always considered as homogeneous (radiative temperature equal to air temperature) and with 50 % relative humidity.

C.2 Metabolic heat production M

$$M = M_b + M_s \qquad (C.2)$$

where

- M_b is the basic metabolic heat production for an activity of lying at rest, expressed in Watt per square metre (W/m^2) (detailed in C.7);
- M_s is the additional metabolic heat production due to shivering, expressed in Watt per square metre (W/m^2) (detailed in C.7).

C.3 Dry heat loss H_c

As ambience is always considered as homogeneous (radiative temperature equal to air temperature), dry heat loss through the sleeping bag is calculated by:

$$H_c = \frac{(t_{sk} - t_a)}{R_{c,eff}} \quad \text{(C.3)}$$

where

- H_c is the dry heat loss through the sleeping bag, expressed in Watt per square metre (W/m^2);
- t_{sk} is the mean skin temperature of the sleeping bag user, expressed in degrees Celsius (°C), which depends on physiological stress retained (detailed in C.7);
- t_a is the ambient air temperature, expressed in degrees Celsius (°C);
- $R_{c,\,eff}$ is the effective thermal resistance of the sleeping bag, expressed in square metre Kelvin per Watt (m^2 K/W). The effective thermal resistance is related to the thermal resistances $R_c(1)$ and $R_c(2)$ according to C.7 and thus like other factors, depends on the posture adopted by the sleeping bag user in the bag:

C.4 Evaporative heat loss H_e

$$H_e = \frac{w(p_{sk} - p_a)}{R_{e,eff}} \quad \text{(C.4)}$$

where

- H_e is the evaporative heat loss, expressed in Watt per square metre (W/m^2);
- w is the skin wettedness (see (C.5));
- p_{sk} is the partial water vapour pressure on wetted skin, expressed in Pascal (Pa), (see (C.6));
- p_a is the partial water vapour pressure in the ambient air, expressed in Pascal (Pa), (see (C.7));
- $R_{e,\,eff}$ is the effective water vapour resistance of the sleeping bag, expressed in square metre Pascal per Watt (m^{2}Pa/W) according to C.7 and thus like other factors depends on the posture adopted by the sleeping bag user in the bag.

Skin wettedness (*w*) may be regarded as the proportion of skin area which is exposed to and participates in evaporation. The value retained for activity of resting in cold conditions is 6 %, which corresponds to insensible perspiration:

$$w = 0{,}06 \quad \text{(C.5)}$$

Water vapour pressure on wetted skin is given by:

$$p_{sk} = p_{sat}(t_{sk}) \quad \text{(C.6)}$$

where

- p_{sk} is the water vapour pressure on wetted skin, expressed in Pascal (Pa);
- t_{sk} is the mean skin temperature of the sleeping bag user, expressed in degrees Celsius (°C), which depends on physiological stress retained (see (C.7));
- $p_{sat}(t_{sk})$ is the saturated water vapour pressure at skin temperature t_{sk}, expressed in Pascal (Pa) and calculated by (C.8).

Partial water vapour pressure in the ambient air is:

$$p_a = Rh_a / 100 \cdot p_{sat}(t_a) \quad \text{(C.7)}$$

where

p_a is the partial water vapour pressure in the ambient air, expressed in Pascal (Pa);

Rh_a is the relative humidity in the ambient air, expressed in per cent (%);

t_a is the ambient air temperature, expressed in degrees Celsius (°C);

p_{sat} (t_a) is the saturated water vapour pressure at temperature t_a, expressed in Pascal (Pa) and calculated by (C.8).

$$p_{sat}\ (t) = 133{,}3 \cdot 10\ \exp\ [\,-\ 2919{,}611/(t + 273) - 4{,}79518\ \log\ (t + 273) + 23{,}03733] \quad \text{(C.8)}$$

NOTE t is either t_a or $t_{sk.}$

where

p_{sat} (t) is the saturated water vapour pressure, expressed in Pascal (Pa), at temperature t;

t is the temperature, expressed in degrees Celsius (°C).

The effective water vapour resistance $R_{e,eff}$ of the sleeping bag is related to the effective thermal resistance $R_{c,eff}$ and to the effective water vapour permeability index $i_{m,eff}$:

$$R_{e,eff} = 60 \cdot R_{c,eff} / i_{m,eff} \quad \text{(C.9)}$$

where

a) sleeping bag user fighting against cold, with the user completely inside the sleeping bag and curled up to minimize the thermal loss:

$i_{m,eff}$ = 0,54

b) sleeping bag user not fighting against cold, with the user completely inside the sleeping bag but lying in a relaxed posture (for instance lying on the back):

$i_{m,eff}$ = 0,52

c) sleeping bag user fighting against overheating, with the user not completely inside the sleeping bag (for instance with the arms lying outside the sleeping bag):

$i_{m,eff}$ = 0,30

C.5 Respiratory heat loss H_{res}

$$H_{res} = M \cdot [0{,}5524 - 0{,}00144 \cdot (t_a + 273) - 0{,}00632 \cdot p_a/(t_a + 273)] \quad \text{(C.10)}$$

where

H_{res} is the respiratory heat loss, expressed in Watt per square metre (W/m^2);

M is the metabolic heat production, expressed in Watt per square metre (W/m^2), issued from (C.2);

t_a is the ambient air temperature, expressed in degrees Celsius (°C);

p_a is the partial water vapour pressure in the ambient air, expressed in Pascal (Pa), calculated according to (C.7).

C.6 Change of body heat content ΔS

Change of body heat content results in decreasing or increasing internal body temperature. The physiological model presented here is made for thermal equilibrium, and thus the change of body heat content is assumed to be zero:

$$\Delta S = 0 \text{ W/m}^2 \quad \text{(C.11)}$$

C.7 Physiological data assumed for calculation of temperatures of utility

C.7.1 Extreme temperature T_{ext}

This temperature is calculated for a person with characteristics of a so-called standard woman (25 years old, 60 kg, 1,60 m, 1,62 m² body surface area) in a situation of high cold stress, combined with shivering to increase the basic metabolic heat production, which can be maintained only for a limited duration of 6 h. The sleeping bag user is curled up in the sleeping bag so as to minimize thermal loss through the sleeping bag. The data for this temperature consists of:

a) basic metabolic heat production: M_b = 44,4 W/m²;

b) additional metabolic heat production due to shivering: M_s = 25,4 W/m²;

c) effective thermal resistance of the sleeping bag $R_{c,eff}$: $R_{c,eff} = R_c(1)$;

d) effective water vapour resistance of the sleeping bag $R_{e,eff}$: $R_{e,eff} = 60 \cdot R_{c,\,eff}/0{,}54$.

C.7.2 Limit temperature T_{lim}

This temperature is calculated for a standard man (25 years old, 70 kg, 1,73 m, 1,83 m² body surface area) in a situation of fighting against cold (posture is curled up inside the sleeping bag), but in thermal equilibrium and just not feeling cold (no shivering). The data for this temperature consists of:

a) basic metabolic heat production: M_b = 47,5 W/m²;

b) effective thermal resistance of the sleeping bag $R_{c,eff}$: $R_{c,eff} = R_c(1)$;

c) effective water vapour resistance of the sleeping bag $R_{e,eff}$: $R_{e,eff} = 60 \cdot R_{c,\,eff}/0{,}54$.

C.7.3 Comfort temperature T_{comf}

This temperature is calculated for a standard woman (25 years old, 60 kg, 1,60 m, 1,62 m² body surface area) who is just not feeling cold (no shivering) in a relaxed posture. The data for this temperature consists of:

a) basic metabolic heat production: M_b = 44,4 W/m²;

b) effective thermal resistance of the sleeping bag $R_{c,eff}$: $R_{c,eff} = 0{,}9 \cdot R_c(1)$;

c) effective water vapour resistance of the sleeping bag $R_{e,eff}$: $R_{e,eff} = 60 \cdot R_{c,\,eff}/0{,}52$.

C.7.4 Maximum temperature T_{max}

This temperature is calculated for a standard man (25 years old, 70 kg, 1,73 m, 1,83 m² body surface area) in a posture with his arms lying outside the sleeping bag, The data for this temperature consists of:

a) basic metabolic heat production: $M_b = 48,1\ W/m^2$;

b) skin wettedness: $w = 0,35$;

c) effective thermal resistance of the sleeping bag $R_{c,eff}$: $R_{c,eff} = R_c(2)$;

d) effective water vapour resistance of the sleeping bag $R_{e,eff}$: $R_{e,eff} = 60 \cdot R_{c,\ eff}/0,30$.

C.8 Approximate calculation of the temperatures of utility

The limiting temperatures of a sleeping bag may be approximated using the following formulae:

$$T_{ext} = -50,91 \times R_c(1) + 29,61 \quad \text{(C.12)}$$

$$T_{lim} = -36,35 \times R_c(2) + 32,00 \quad \text{(C.13)}$$

$$T_{comf} = -30,96 \times R_c(1) + 32,29 \quad \text{(C.14)}$$

$$T_{max} = -36,07 \times R_c(2) + 38,19 \quad \text{(C.15)}$$

Annex D
(informative)

Warning of misuse of temperature rating

The insulation of a sleeping bag varies widely with the conditions of use (wind, radiative ambience, posture and clothing of the sleeping bag user, ground insulation, eventual humidity in the sleeping bag etc.).The perception of cold of the user is also individually different (influence of acclimatisation, physical and psychological state, food etc.).

The limiting temperatures of the range of utility as determined in this European Standard only compare performance of sleeping bags with regard to standardised test conditions. They do not take into account all possible variations in conditions of use and in individual reactions, and therefore should be considered only as a guideline, that needs personal adaptation for practical use.

In particular, it shall be noted that the extreme temperature is a very theoretical limit. It shall therefore only be considered as a point of danger that should not be approached - unless the sleeping bag user has a wide personal experience.

The determination of the comfort temperature uses the available knowledge of published data and is based on the thermal balance of the whole body. The human body is very sensitive to local discomfort: a local thermal bridge might not influence the global insulation of the sleeping bag, but might greatly affect the sensation of cold of the sleeping bag user. It shall be emphasised that the test method in this European Standard does not provide any guarantee against local cooling.

The temperatures of the range of utility relate to indoor conditions. For outdoor use, wind may affect insulation of the bag to a large extent, especially if the shell fabric of the sleeping bag is air permeable.

In this European Standard, sleeping bags are considered as dry. High moisture content might lower thermal performance.

Annex E
(informative)

Rationale

The primary aim of this European Standard is to provide information to the consumer by specifying a test procedure and an evaluation model to quantify the thermophysiological function of sleeping bags.

This function is determined by the sleeping bag's thermal insulation and by its moisture management properties. Both shall be adapted to the ambient climate conditions (temperature, humidity, wind speed) under which the sleeping bag is used, as well as to the physiological processes in the human body. A correct adaption is the prerequisite for good sleep quality and is achieved if the body's heat content is balanced. This means that the heat which is always (i.e. also with a sleeping person) created within the body by metabolic processes shall be dissipated in the same amount as it is produced. Generally maintaining this heat balance in a sleeping bag is made difficult by the fact that, on the one hand, the amount of metabolic heat within the body depends on the person's weight. For example, while sleeping, a 50 kg person produces around 60 W heat, while a 110 kg person produces about 100 W. On the other hand, the heat flow from the sleeper's body to the surrounding air is not only determined by the sleeping bag's thermal insulation to which the thermal insulation of the sleepwear and possibly of the mat underneath the sleeping bag has to be added, but also by the ambient temperature. If this heat flow is too high, the body's heat content decreases, and the person will feel cold and, in extremer cases, can even die due to hypothermia.

If the heat flow is too low, the body's heat content increases, and the person begins to sweat. The purpose of this process is to cool the body via the evaporation of sweat on the skin. This cooling is quite effective, but only if the sweat can actually evaporate. This means that the sleeping bag shall also have a good "breathability". This demand is underscored by the fact that a person, even without actively sweating, in any case during the night dissipates about ¼ litre of moisture from the body's interior through the skin. If the sleeping bag's "breathability" or moisture management is not good enough, the person will not only feel uncomfortably moist, but also the body will be overheated, with the sleep being impaired or even made impossible.

Naturally, the thermophysiological comfort effected by a sleeping bag is determined from a large number of variables. These variables have been taken into account by the test methods with a thermal manikin and a Skin Model described in this European Standard, and by the thermophysiological model used to evaluate the test results and to translate them into the temperature limits of what is called the sleeping bag's range of utility.

With the Skin Model ("sweating guarded-hotplate"), standardized in ISO 11092, the sleeping bag's moisture management is tested and quantified via the water vapour permeability index in 4.4.1. The minimum value of 0,45 demanded for this index ensures that the sleeping bag's "breathability" is at least satisfactory.

With the manikin, standardized in EN ISO 15831, the thermal insulation effected by the sleeping bag is measured. This thermal insulation is not only created by the bag itself, but is also influenced by the garments worn within the bag and the mat possibly placed underneath the bag, as well as, for example, by the person's weight compressing the bag's bottom part, and by the ambient wind speed and humidity. Therefore, in this European Standard, test conditions have been defined in such a way that the test results are repeatable and also comparable between different test houses. This has been verified by several round robin tests performed prior to the publication of this European Standard, with the precision achieved given in Annex B.

More particularly, the test conditions chosen also take into account that in practical use in a cold climate a person will turn the head into the sleeping bag's hood in order to protect the face from cold air. Because the head of the manikins presently available the head cannot be turned, for sleeping bags including a hood, this situation is simulated by placing a mask on the manikin's face.

Similarly, the test conditions also take into account use in a hot climate. Due to the fact that at higher ambient temperatures it would be unrealistic to use the sleeping bag completely closed, and with the hood tight around the head, a second posture for the manikin is specified. In this second posture, the bag's zippers are fully opened and the hood is turned down, leaving the manikin's arms and shoulders, as well as the head, uncovered.

The thermophysiological model applied in this European Standard to convert the sleeping bag's thermal insulation into its temperature range of utility is the result of extensive physiological research. The limiting temperatures derived from this evaluation model have been proved to be correct by numerous sleep trials with human subjects performed scientifically by different research institutes. These sleep trials have been conducted in climatic chambers with controlled ambient climate conditions, and with sensors attached to the subjects' body, transmitting physiologically relevant data such as rectal and skin temperatures, humidity next to the skin, metabolic heat and sweat production of the subjects, as well as sweat uptake of the sleeping bag and sleepwear. Via the heart rate, the sleep quality was monitored; and the persons' subjective comfort sensations were quantified via scales in questionnaires.

It can be stated in general that the thermophysiological model used in this European Standard to determine a sleeping bag's range of utility out of its effective thermal insulation is not the only one possible. However, this model is the only one of its kind to date whose results have been scientifically validated with statistically sufficient accuracy.

In particular, this thermophysiological model takes into account that, as outlined above, a person's metabolic heat production depends on their weight, and the heat flux from the body on its surface area (which also depends on weight and additionally on height).Because of this variability, the model differentiates between a heavier and taller "standard man" with a higher metabolic heat production while sleeping, and a comparatively lighter and smaller "standard woman" with a lower heat production within her body. The "standard woman" starts to feel cold in the sleeping bag at the "comfort temperature" introduced in the standard, whereas the "standard man" starts to be uncomfortably cold at the "limit temperature" which, depending on the sleeping bag's thermal insulation, is several °C lower than the "comfort temperature".

Below the "limit temperature" practically everybody feels too cold, and when approaching the "extreme temperature" the "standard woman" is in danger of suffering health-damaging hypothermia. At the "maximum temperature" however, a person with a body stature similar to the "standard man" will feel uncomfortably hot in the sleeping bag.

These temperatures, limiting the range of utility of a sleeping bag, and depending on its thermal insulation, are shown in Table 1 and Table 2. The intention of the standard is that at the Point of Sale sleeping bags are marked with these temperature limits. Such a marking provides the consumer with an objective criterion to compare different sleeping bag products with regard to their physiological performance, and helps them to select a product which is physiologically suitable for the climate conditions in which it is intended to be used.

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