Sleep Well

Part 1 | Temperature Ratings

A Review of Temperature Standards
for Sleeping Bags

CONTENTS

1 INTRODUCTION

Over many years, several standards for temperature ratings of sleeping bags have been devised. Each test has its supporters and detractors. Test methods have been developed by scientists in Great Britain, France, Germany, Norway, America and Switzerland. Although each brand based its recommendations for comfort temperatures on their own tests, the levels among the quality high level brands were broadly similar. Retailers and consumers understood that these represented ideal conditions and bought cautiously (i.e. a little warmer than it said on the label).

In April 2002, a new European Standard EN 13537, Requirements for Sleeping Bags was approved by CEN. The benchmark comfort temperature values in EN13537 much more conservative than previous commercial practice. Over the next few years the proportion of products in shops that are marked to EN13537 will rise to 50%. However, in theory, legal action could force this to 100% by 2005 (See notes in Chapter 8). As we will have different benchmarks at the point of sale, traditional advice to consumers will become very confused.

In this document our goal is to explain the various tests with a minimum of scientific jargon. Our ultimate goal is that journalists, opinion leaders and retail buyers can make sensible comparisons. Therefore, they can give clear and appropriate advice to consumers.

Which is the warmest?

ANSWER -They are probably all the same!

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Science

2. THE SCIENCE BEHIND SLEEP COMFORT

Before we can even start to examine the sleeping bag rating methods, we must first understand the factors that affect an individual's perception of warmth.

2.1 The Idea of Heat Balance

If we feel warm, then the heat that we are producing is equal or greater than the heat that we are losing to the environment around us. We generate heat through our metabolism.

We lose heat through:
- Conduction to surfaces we touch, especially the ground below us.
- Convection as air circulation carries away heat and respiration losses from heat in the air we exhale.
- Evaporation of moisture from our skin (mostly sweat)
- Radiation of infra red heat.

The most important losses for a sleeping person are conduction and convection.

For comfortable sleep, we must have heat balance.

Heat Generated

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Heat Lost through Convection, Conduction, Evaporation, and Radiation

Convection is the major loss that is reduced by a sleeping bag. The main purpose of the sleeping bag is to trap warm air in a thick layer around the body.

Conduction to the ground is a major factor. The sleeping bag has some influence but the choice of sleeping mat is also a major influence.

Respiration In cold environments, the losses through respiration also become a significant factor.

Evaporation of sweat is an important cooling method used by the body when it gets too hot. When we are sleeping in a cool environment, the impact of evaporation is small.

Radiation is a very small part of our heat loss (despite the myths put about by sellers of space blankets).

2.2 Physiological factors

A sleeping bag only retains heat. The person inside is the generator of the power to keep warm. Next, we will look at the influence on this power output and the differences found between individuals and situations. All ratings systems are based on a standard person. However, the first problem is that there is no such thing as a standard person.

Metabolic Heat Output - A sleeping man generates between 75 and 100 Watts of heat. For an average built man, this translates into a heat output per square metre of surface area of between 47 to 55 W/m^2. However metabolic heat output is a very complex issue involving body fat index, age and sex. In general, young well nourished men produce more body heat than older men and much more than women. The sensation of cold is also linked to age and conditioning. Novices feel the cold more than experienced mountaineers. People who work outside feel more comfortable in cold environments than people who work in offices. After the age of 25, it is generally true to say that heavy people feel the cold less than slim people.

Heavy or slim - Fat people often say that they have a slow metabolism. It is more accurate to say that they eat more than they burn up. Slim people have a balanced metabolism - they eat as much food as they burn. Body fat has a big impact when the food intake is less that the energy output. Backpacking and trekking often leads to a situation where you eat less calories than you burn. Polar and high mountain expeditions face a situation where it is impossible to eat enough to match the energy requirements. The fat person will be able to burn energy from their fat reserves. Also the fat person has more natural insulation than the thin person. So it is true to say that a fat person feels the cold less than a thin person.

Sex - Women are generally colder than men. In EN 13537, the comfort value for a standard woman is 5 ºC higher than for a standard man.

Age - However, metabolism is age related. Older people generate less heat and hence feel cold more than younger people. In particular, well fed young men between 16 and 24 have a high metabolic rate and demonstrate "dietary induced thermo-geneses". In other words, their bodies pump out heat so they do not feel the cold. So for a young male, the comfort temperature could easily be 5 ºC colder than for an older man. Children, especially small children do not have the same natural heat controls as adults. Their metabolism speeds and slows as they grow. For this reason, it is exceptionally difficult to define temperature ratings for children.

Conditioning - Most historical research on sleeping bags was done on soldiers, outdoor instructors, mountain guides and expedition mountaineers. These are a group of fit experienced people, predominantly males 18 to 40, conditioned to living outdoors. Most westernised people live in centrally heated houses, work in air conditioned offices and drive everywhere. This lifestyle reduces the body's conditioning against cold.

Experience - Experience in sleeping in the outdoors also affects the comfort temperature. Experience and familiarity with equipment helps get the best performance from it. A novice will generally feel colder than an experienced person.

Fitness - If a sedentary person goes on a strenuous trip into the wilderness or high mountains, they will quickly become fatigued. Exhaustion reduces heat output and means you feel cold. When they stop exercising, unfit people feel the cold more than fit people.

2.3 Basic Definition of Comfort and Extreme Values

Comfort Temperature is the range of temperatures at which the user gets full nights sleep. Usually this is defined as an upper and lower limit.

The **Upper Limit of Comfort** is the highest temperature that you can sleep without sweating profusely. Usually this is defined with the ventilation zippers open, arms outside the bag and the hood open.

The **Lower Limit of Comfort** is usually defined as the lowest temperature at which a person has eight hours of sleep without waking.

Extreme Temperature is the lowest temperature at which the sleeping bag protects the user from hypothermia.
This is subject to a variety of conditions but is usually defined as six hours of uncomfortable sleep without diminishing the body core temperature to a dangerous level.

Problems with Commercial Practice – Before EN 13537
A problem with these values is that they were originally defined based on an expert young male user (typical soldier or mountaineer) rather than a novice consumer. A second problem is that it is often defined including clothing such as mountaineer's underwear.

3. HISTORY

3.1 Historical Background Chart

C.3500 BC	Otzi, the first known alpinist, had sophisticated insulated clothing and footwear (Tyrol, Alps)
C.2630 BC	Measurement developed to enable the building of the pyramids (Egypt)
C.270 BC	The Roman legions are established with standardised weapons, military equipment and clothing. (Italy)
1593	Galileo creates first thermometer (Italy)
1714	Fahrenheit creates mercury thermometer (Germany)
1742	Celsius invented the Celsius (Centigrade) scale (Sweden)
C.1750-1850	The industrial revolution leads to mechanised mass production of textiles. (Britain, then all Europe)
1855	Establishment of Ajungilak (Norway)
1861	The American Civil War leads to the development of quality control techniques and tolerance systems to make rifles with interchangeable components. (America)
1861	Francis Fox Tuckett tests his prototype alpine sleeping bag, recording ambient temperature.
1865	First Ascent of Matterhorn by English mountaineer Wymper
C.1890	First commercial sleeping bag production by Ajungilak (Norway)
1892	Alpine Club Technical Committee reports on a down sleeping bag
1911	Norwegian Roald Amundsen reaches the South Pole
1930s	Thermal resistance measurement used to measure insulation of clothing
1939	First ever thermal Manikin built by General Electric to test an electric blanket (America)
1941	Development of the Clo unit by Gagge, Burton, and Bazett
1942	Copperman thermal manikin built by US Army researcher Dr Harwood Belding
1953	First ascent of Everest by Sir Edmund Hillary and Sherpa Tensing
1957	The Treaty of Rome leads to the formation of the European Union and common market.
1962	First sweating manikin built by US Army researcher Dr Woodcock
1980	Kansas State University publishes paper on testing sleeping bags with a Copperman manikin. As a result, The North Face was the first brand to send sleeping bags for testing on a manikin.
1984	US Army researchers begin using SAM (sweating articulated manikin).
1994	Norme Française G08-013 - French Standard for requirements for sleeping bags.
1996	ASTM F1720 - US standard for sleeping bag tests with manikin EMPA Sweating Manikin Tests
1997	SINTEF benchmark manikin tests with human trials for Ajungilak (Norway)
2002	EN13537 ratified by CEN as the European Norm for Sleeping Bags

3.2 The Early Development of Sleeping Bags

by Mike Parsons am Mary B Rose;
Authors of Invisible on Everest, innovation and the gear makers

From Animal skins to commercially made sleeping bags

Animal skins
Early man used animal skins for both clothing and as sleeping mats (indeed they are still used today in some polar regions). When textiles arrived around 5,000 BC these were also used to provide ground insulation.

New experiences and early designs
Nineteenth century explorers and mountaineers experimented with sleep systems of various kinds. Early sleeping bags were made from woven camel hair (a natural hollow fibre) with excellent insulation properties. From this, the concept of a complete sleeping bag that gives protection from the cold ground was born. Further insulation came from rubber inflatable mattresses, first introduced to Polar exploration in the 1820s, shortly after Charles Macintosh was granted his rubber patent in 1823. In 1861 Francis Fox Tuckett tested his first prototype alpine sleeping bag and, by the mid 1860s, a design of a blanket sleeping bag had been perfected, with the underside covered with the rubber coated fabric Macintosh. This design continued to be advertised until the 1920s.

Down as an insulator
Down has a long pedigree as an exceptional insulator and was common in Continental bedding by the nineteenth century. In Victorian Britain, women wore down petticoats under their crinolines. However, techniques for using and processing down developed through the nineteenth century. The first recorded use of down sleeping bags was by Alfred Mummery and team in 1892. These were from patterns developed by the Alpine Club and made by the London furnishing company, Heals of Tottenham Court Road. Sleeping bags were not, however, commercially made in this period. The early sleeping bags, whether blankets or down were custom made for expeditions and development and improvement involved interaction between users and makers. The users would simply go out and sleep in the sleeping bags of their own design and then return to the crafts people who made them with suggestions for improvement. Polar explorers continued to use reindeer skin sleeping bags until well after the Second World War. The expeditions and mountaineers shared their experiences through organisations such as the Alpine Club and the Royal Geographic Society.

Commercial sleeping bags
Ajungilak was established as a manufacturer of insulation in 1855 and began producing sleeping bags by about 1890 making them the probably the oldest sleeping bag manufacturer. Another early manufacturer was Woods of Canada (now defunct) also about 1890/5. The first commercial sleeping bags were probably filled with kapok. Kapok (the hollow seed from an Asian tree) continued to be used until the advent of synthetic fibres for sleeping bag wadding.
Sleeping bags remained a specialist product until the 1920s but, in the UK, encouraged by the widening market for hiking and camping, one or two companies, including

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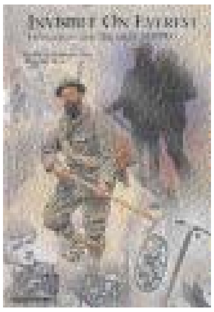
Camtors, Blacks and Robert Burns began to supply cheaper bags. Specialist sleeping bag development continued during the 1930s as a result of the demands of both Himalayan and Alpine climbing. The 'Mummy bag', (named after the Egyptian sarcophagus shape) with its close fit and tapering base, was developed in this period. In 1933/4 the French climber Pierre Allain took down to new heights - literally. Whilst George Finch, on the British 1922 Everest Expedition, can justly claim to be the first person to create a down garment, it was Allain who developed a system to handle the demands of bivouacs on Alpine face climbs combining a short sleeping bag -the pied d'éléphant- and in addition, a down jacket which were all protected from the weather by a long, loose smock of rubberised silk - the cagoule.

Synthetics

The advent of polymers and fibres of same from 1937 onwards revolutionized everything from ropes to tents and even to ski wax, and the sleeping bag was also affected by this revolution from the 1960s. Wadding fibres have undergone much evolution, very often trying to emulate nature and other times simply offering products affordable by all. The warmth/weight ratio of down is still yet to be equalled by synthetic fibres, but the latter have brought advantages of their own.

The never-ending quest for a sleeping bag with a suitable balance of breathable/water resistant/waterproof/down-proof covers for sleeping bags is also part of this evolution and revolution. A hundred and fifty years ago Francis Tuckett had found that using an impermeable cover, such as Macintosh, (rubber accorded fabrics) was disastrous because of condensation. Until the 1960s, climbers spent much of their time covered in down because covers were not down-proof. As the market grew then new textile processes became available which allowed not only fully down proof fabrics (Pertex being an interesting example) but fully waterproof using microporous coatings or laminates (of which Gore-Tex is a prominent example).

Invisible on Everest: Innovators and Gear Makers
The first ever 200 year history of the great innovations of mountaineering and outdoor equipment.



Mike Parsons and Mary B. Rose.
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3.3 Historical Development of Sleeping Bag Testing

The Nature of Science

Science is not a fixed subject. Over time research changes the perception of an issue. First a hypothesis is created. Then experiments are developed to check if the hypothesis works. If the experiments work, they are communicated to other scientists. Problems encountered with one series of experiments stimulate more research which in turn leads to new experiments.

Similarly product testing begins with simple experiments to see if repeatable results can be achieved. If a test produces consistent results, it becomes accepted as a benchmark by other researchers. Further work to prove the consistency leads it to become a standard test method suitable for publication or commercial use.

Temperature Ratings

From about 1930, hiking and camping became popular throughout Europe. In turn this created a supporting industry of equipment manufacturers. As sleeping bags evolved into commercial products, the manufacturers started to label the products so that consumers could understand whether the product was suitable for their needs. At first the ratings were simply summer, three season or winter use. Later, as retail sales developed, manufacturers began to give ratings to sleeping bags. This rating was a rough guide to the lowest temperature that the sleeping bag could be used.
Later still, some brands began to give two values - a Comfort value and an Extreme value. The Extreme value was an indication of the lowest temperature for survival use and the Comfort temperature was the lowest temperature for a full nights sleep.

Field Testing

To establish the temperature ratings of sleeping bags, prototypes were given to users who were often sleeping in the outdoors. Typically, these were expert users like mountain guides. They would use the product for several weeks and give the manufacturers their opinion on the suitable comfort and extreme ratings.

Textile Tests

By the 1930s, Thermal resistance textile tests were commonly used to evaluate the performance of insulative clothing. As the sleeping bag industry grew more professional, brands began to use these textile tests to measure different insulation materials. It is relatively cheap and easy to measure the insulative properties of the materials in the sleeping bag. Typically these tests rely on a square of the fabric and insulation material about 35cm x 35cm. This can either be cut from a finished sleeping bag or made up from the raw materials.

Units of Measurement

In 1941, American scientists created a standard measurement unit for insulation - the Clo. One Clo was the insulative power of a typical business suit. Under the SI metric system of measures, the fundamental unit of thermal resistance is the m^{2-}K/W. Scientists found this value difficult to explain to non scientists, so the Shirley Institute in Britain developed an easy to follow unit of insulation, the Tog. The Shirley Togmeter was launched in the 1960s

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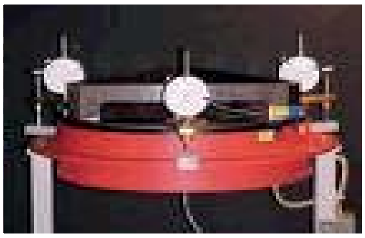
and is the standard apparatus for BS4745 commonly known as the Tog Test.

1 tog = 0.1 m^2 K/W = 0.645 Clo
1 Clo = 0.155 m^2 K/W =1.550 tog



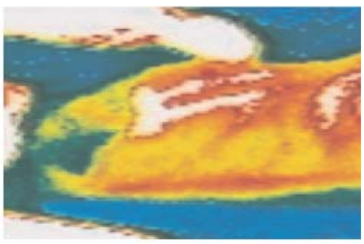
Shirley Togmeter

The textile tests allowed a clear precise measurement of the insulation in the sleeping bag. However, to use this data for a whole sleeping bag, you need to cross reference it with human users. Field trials were performed as previously with expert users. However, now the researchers equipped the testers with thermometers and logbooks to record the actual overnight temperature. (Francis Fox Tucket actually did this himself one hundred years earlier on an 1863 expedition) This data was used to improve the correlation of results.

Climate Chambers
It is very difficult to get mountain guides to record accurate data for scientists. To make comparisons, the scientists needed temperature, wind-speed, humidity, clothing etc. The logical step was to seek out an environment with controlled ambient temperature and humidity. The researchers looked for convenient places where the temperature was very cold and the humidity controlled. The first answer was meat packing plants. Researchers would hire an area in the cold storage unit and sleep overnight. After several nights in different sleeping bags they were able to build graphs relating the insulation values from the textile tests to the perceptions of comfort established by human user trials. The next step was to build climate chambers in research laboratories. These allowed the researchers to vary temperature, humidity and more recently, air velocity.

Thermal Imaging
About 1980, developments in computers lead to the creation of thermal image cameras that were suitable for use in cold chambers. This allowed thermal image pictures of sleeping bags to be taken of a human inside a sleeping bag. These pictures clearly showed the hot spots as red and yellow areas against an outline of blue and green cold areas. These pictures prompted several improvements in the design of sleeping bag zip baffles, hood shapes and foot constructions.

Thermal graphic of sleeping bag



Computerised Data Collection
Those of us who were born before 1970 will remember when computers were a novelty. By the mid 1980s, affordable computers were powerful enough for researchers to link several temperature sensors to one

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computer and collect data at five minute intervals through the night. Scientists began to recruit people as test subjects for sleeping bag research. These subjects were wired up with skin sensors and even rectal thermometers to measure core temperature. In the early days, the sensors were very bulky and had cables attached making them uncomfortable to wear.

For the first time it became possible to gather and analyse masses of data. However, an old problem was encountered. People are very variable. The perception of cold depends on many factors including physiology (body size and metabolism) and conditioning (fitness and experience of sleeping at cold temperatures). A further problem is that humans soon get bored sleeping in cold chambers wired to a computer. They tend to stop doing it after a few times (a very few times if the scientists insist on rectal thermometers!). This made life difficult for the researchers as there were still many uncontrolled variables.

Thermal Manikins

The next obvious step was to build a machine that would simulate a sleeping human. Such a machine would allow the researchers to control the metabolic heat output and body surface area. Also a machine would never get bored or complain about the rectal thermometer. A manikin in a cold chamber would allow the following parameters to be accurately measured or controlled:

- Ambient temperature
- Ambient humidity
- Metabolic heat output
- Body surface area
- Insulation from the ground
- Skin temperature

Each manikin had heating elements to simulate metabolic heat output and sensors to measure skin temperature. These thermal manikins began as heated cylinders that could be inserted into the sleeping bag. These early cylinders did not fill a sleeping bag in the same way as a human. This was not a problem for materials research as the sleeping bag could be reshaped to fit around the cylinder.

The solution was to reshape the primitive machines into something more humanoid in form. As a human has head, trunk, arms and legs, the manikins needed separate heating zones and temperature sensors for each area.

Secrets of the US Army

Forty years earlier, in World War 2, the US army had invested a huge amount into research on clothing and sleeping bags. The Harvard Fatigue Laboratory built the first thermal manikins and climate chambers in 1941. By 1942, one of their researchers, Dr Harwood Belding, had created the Copperman, the first humanoid heated manikin. This work remained secret until 30 years after the war ended.

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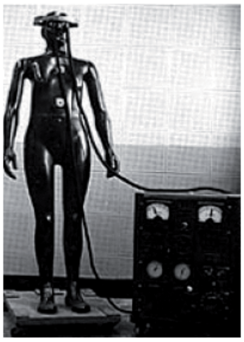


Copperman 1942

Copperman Goes Public

In 1980, Professor McColough of Kansas State University presented a lecture at the Outdoor Retailer Conference on the testing of clothing and sleeping bags using a copper manikin. As a result, The North Face became the first outdoor brand to test their sleeping bags on a thermal manikin.

The early Copperman trials produced controversy within the outdoor industry and after initial excitement, most brands returned to traditional field tests and textile tests. For the next fifteen years, the outdoor brands largely ignored thermal manikins. However, the researchers continued to make and improve manikins and their accuracy. During the eighties and nineties several research establishments attempted to build machines to simulate a sleeping human.

Humanoid Manikins Come of Age

For the European outdoor industry, the breakthrough came from the Hohenstein Institute in Germany whose manikin CHARLIE has 15 zones. This manikin was the first whose results were accepted by the trade.

Soon after, ITFH the French textile research and testing centre created an even better manikin MARTIN with 35 zones. By the mid nineties, development of manikins was sufficient that a few test houses (Institute Hohenstein, ITFH, Leeds University and Sintef were offering manikin test services to the sleeping bag industry. The French went on to create the first standard that related the thermal resistance measurements to the recommended temperatures (Norme Française G08-013).

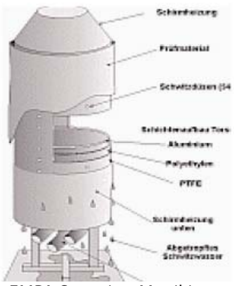
Two test centres - Institute Hohenstein and IFTH, joined together to harmonise their test methods and agree on a common standard to evaluate sleeping bag insulation. This became the standard that developed into EN 13537. Charlie became the benchmark manikin for the EN standard.

Hohenstein Institute "Charlie"

The Sweating Torso

EMPA, the Swiss research institute developed a Sweating Torso to research the effect of perspiration and condensation inside the sleeping bag. In 1996, they measured the effect on the insulation for both down and synthetic sleeping bags. At low temperatures, perspiration leads to moisture that condenses within the sleeping bag. The reduction of insulation power of a down sleeping bag is very large. The effect on a synthetic sleeping bag is much less but still significant.

At low temperatures, perspiration may lead to moisture that condenses within the sleeping bag. The reduction of insulating power of a sleeping bag can be significant.



EMPA Sweating Manikin

3.4 Current Research at EMPA

EMPA also researched and measured sweat and skin temperature at various points on the body. From this they developed a very complex manikin that could simulate a moving sweating human.

SAM Sweating Articulated Manikin

In 2001 EMPA's new manikin came into service. SAM (Sweating Agile Manikin) is a fully movable humanoid manikin that can simulate walking, sitting, standing and sleeping. SAM has an advanced heating system that can create the same skin temperature gradients as found in thermo graphic imagery of humans. SAM lives in his own climate chamber that can simulate cold with wind, rain and even snow. SAM has already been used to assist research into garments for the Swiss Army and several textile manufacturers.

The Sleeping System

The sleeping system is very complex. It can consist of sleeping mat, sleeping bag, garments and socks worn by the sleeper, a liner and a tent or bivi bag. EMPA is undertaking a research project to evaluate the influences on insulation of the various components. The research was originally conceived to develop sleep systems for the army but it should ultimately have a significant impact on products for outdoor enthusiasts. The Swiss Army is one sponsor, and Mammut is another.

3.5 The Need for Standards

Throughout history, consumers have needed to specify exactly what they wanted. The simplest relationships are craftsman and customer. As society became more complex, sophisticated systems were developed to create products with standardised measurements and performance.

Otzi probably gave direct personal instructions to the tailor who made his sophisticated outdoor clothing. However, complicated projects involving many people and great distances could not function in this simple way. The Egyptians needed to develop measurement in order to standardise the stone blocks that they used for the pyramids. The Romans invested huge efforts into standardisation of military uniforms training and equipment as they created the legions and conquered the world.

In the 1750s, the industrial revolution changed the world. Over the next century, manufacturing moved from handwork to machine work. At the same time transport systems were revolutionised enabling mass movement of raw materials and finished goods. Cities grew around the manufacturing and transport centres. New types of businesses grew up including for the first time, branded goods sold through retail shops. These businesses needed to establish quality control standards and tests to verify that the goods were "up to standard". Britain lead this revolution and the establishment of standards. "British Standards" became the benchmarks in world trade. France and Germany also developed strong national bodies for the creation of standards.

However, it was the American Civil War (1861) which caused the biggest breakthrough in manufacturing standardisation. This was a war of attrition, where mass production contributed to ultimate victory. Huge numbers of rifles were produced with interchangeable parts enabling the Union to win the war.

Brands were mostly regional until the Second World War. For the first time in history, Europeans and Americans were stationed all over the world. Some enterprising (mostly American) brands ensured that their product was available wherever their soldiers were situated. Hence, globalisation of consumer markets was set into motion resulting in Coca

Cola becoming the most widely recognised product in the world. Behind this success is a standardisation mentality to ensure that the product always looked and tasted the same wherever it was purchased or consumed.

The Treaty of Rome in 1957 saw the establishment of the European Common Market. A new movement started to harmonise various national standards. A system called European Norm (EN) was established by the CEN (European Committee for Standardization) and gradually the EN has become the binding standard in all European countries.

Throughout history, standards have been essential parts of the strategy of successful governments and businesses. However, some critics see a new phenomenon occurring in Europe. There is no doubt that harmonisation of standards has made goods safer. However, a huge industry of competing test houses and national bodies has grown up from this process. The standardisation process sometimes appears unstoppable and divorced from consumer needs.

Important Standards for Sleeping Bags
- BS4745-1984 Thermal Resistance of Textiles
- ISO 5085 Thermal Resistance of Textiles
- EN 31092 Thermal Resistance of Textiles
- ASTM F 1720 - 96, Standard test method for Measuring Thermal Insulation of Sleeping Bags Using a Heated Manikin
- Norme Francais G08-013 Requirements for Sleeping Bag
- EN 13537:2002 Requirements for Sleeping Bags

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United States Military Use of Thermal Manikins in Protective Clothing Research.
Thomas L. Endrusick, Leander A. Stroschein and Richard R. Gonzalez
(Available at www.mtnw-usa.com/thermalsystems/history.html)

4. UNITS OF MEASUREMENT

The measurement of Insulation uses some complex terms. The measurement units are a function of power and temperature change per square metre. However, the bedding and clothing industries have popularised two units, the Clo and Tog. Thankfully, their origins and interrelationship is fairly easy to explain.

4.1 CLO Value

The development of the clo unit in 1941 by Gagge, Burton, and Bazett was an important advancement in clothing science as it provided for a standard measure of the thermal insulation of clothing. This concept of insulation was intentionally developed to be understood by non-scientists and was the first to establish a relationship between man, his clothing and the environment.
CLO is a unit of insulation for clothing (it was defined as the amount of clothing required by a resting subject to be comfortable at a room temperature of 21°C). One CLO corresponds approximately to the value of a typical business suit.

4.2 TOG Value

The Tog system for describing the thermal insulation properties of textiles originated at the Shirley Institute in the 1960's and the Shirley Togmeter was devised for measuring insulation values. As scientists adopted the System International Units (I.e. the Metric System), the fundamental unit of Thermal Resistance became m^2 K/W. To explain this complicated looking value to consumers, the scientists simply multiply it by ten and express it as a whole number. This whole number is the TOG value. Bedding manufacturers popularised this value as a rating for duvets. TOG is still a popular unit in magazine articles about textiles.

1 Tog = 0.1 m^2 K/W = 0.645 Clo
1 Clo = 0.155 m^2 K/W = 1.550 Tog

4.3 Comparison of Thermal Resistance Values

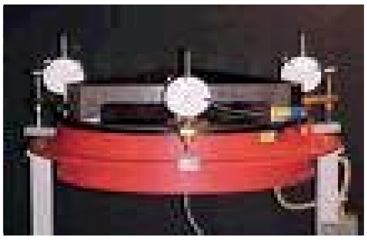
			Typical sleeping bag terms	
M^2 K/W	Tog	Clo	Description	Season Rating
0.1	1	0.65		
0.155	1.55	1		
0.3	3	2		
0.4	4	2.5	Summer	1 Season
0.6	6	4	Spring	2 Season
0.9	9	6	3 season	3 season
1.0	10	6.5	Winter	4 season
1.2	12	8	Mountain	4+ season
1.55	15.5	10	Arctic	

5. TEXTILE TESTS

Laboratory tests to determine the thermal resistance of textiles date back to the 1930s. There are many variations but here, we will only describe two BS4745 – 1984 and ISO 5085-2 1990.

5.1 BS4785-1984

This test is known popularly as the TOG test and dates from the 1960s. It became famous when the bedding industry adopted it as the standard for defining the warmth of blankets and duvets.



Shirley Togmeter

A sample of the fabric or insulating wadding to be tested is placed over a heated plate. The test machine is called a guarded hotplate and is encased in a fan assisted cabinet. The fan ensures enough air movement to prevent heat build up around the sample and also isolates the test sample from external influences. A disc shaped sample 330 mm in diameter is heated by means of a metal plate and the temperature on both sides is recorded using thermocouples. The test takes approximately three hours including warm up time. The thermal resistance is ca culated based on the surface area of the plate and the difference in temperature between the inside and outside surfaces. Results from the BS 4785 tests are quoted in togs or in m2 K/W.

5.2 ISO 5085-1 1989 and ISO 5085-2 1990

The ISO test has two methods. Part 1 is for fabrics of low thermal resistance – up to 0.2 m^2 K/ W but can also be used for samples up to 0.4 m^2 K/ W provided they are less than 20mm thick. Part 1 uses a guarded hotplate apparatus and is similar to BS4785 above.

Part 2 is for thicker fabrics with high thermal resistance – between 0.2 m^2 K/W and 2.0 m^2 K/W. Sleeping bags fall in the range specified by Part 2. This test is done in a climate controlled room or cabinet. A rectangular sample of material (600mm x 450mm) is placed on a table containing a heated plate underneath the sample. The apparatus is left for at least four hours to achieve a steady temperature state. The power needed to maintain a constant temperature is measured. From this the
thermal resistance is calculated based on the surface area of the plate and the difference in temperature between the skin surface and the environment. Results from the ISO 5085 tests are quoted in m^2 K/W.

5.3 Leeds Comfort Model

Textile tests produce an idealised result. The materials are laid flat over the heating elements and are not subjected to the localised stretching or crushing that is found in a completed sleeping bag. Also, the effects of shape and baffle design of the sleeping bag cannot be measured. To relate the textile test results to sleeping bags in practice, human user trials are needed.

The Department of Performance Textiles at Leeds University developed a comfort model to relate the thermal resistance of sleeping bags to the temperature recommendations. This model was one of the first to be published and is often quoted in articles by the outdoor trade press. It has been widely used by British sleeping bag makers.

Table Comfort Temperatures from Tog Test (Leeds)

M^2 K/W	Tog	Clo	Comfort °C
0.4	4	2.5	15
0.6	6	4	9
0.9	9	6	0
1.0	10	6.5	-10
1.2	12	8	-20
1.55	15.5	10	- 30

6. MANIKIN TESTS

The main manikin tests are described approximately in chronological order. The American test comes first as it dates back to before 1980 even though it only became a standard in 1996. To avoid repetition, details that are common to the various tests are described once. Thus a typical manikin test procedure is described in chapter 6.1 and typical experiments to relate a manikin test to a human user trial are found in chapter 7.2.

6.1 ASTM F 1720-96 gives a result for the thermal insulation of the sleeping bag in CLO

This is a standard which describes the procedures to determine the insulation of a sleeping bag by measuring the dry heat transfer to a cold environment.

Test Procedure
Each sleeping bag is unpacked, shaken for a minute and left to rest for 24 hours. A nude heated manikin is placed inside the sleeping bag and the whole assembly is placed in a cold environmental chamber (0 °C). The humidity and the air movement are minimised. The manikin rests on a camp bed within the environmental chamber.

The manikin is heated and the whole assembly is left to stabilise i.e. until the skin temperatures and power input becomes constant. For the test, measurements of the power and temperatures are taken at five minute intervals for 30 minutes. The power needed to maintain a constant body temperature is measured. From this the thermal resistance is calculated based on the surface area of the manikin and the difference in temperature between the skin surface and the environment.

ASTM F 1720-96 gives a result for the thermal insulation of the sleeping bag in clo. By preference three identical sleeping bags are tested. However, if only one prototype is available, the test can be performed three times. The standard does not give any recommendations of a Comfort model relating the temperature values to the measured thermal resistance.

6.2 Norme Française G 08-013 1994

The French standard was the prototype for the European norm and also the first to define a comfort model which relates the thermal resistance to the published Comfort and Extreme temperature values.
It was also the first test to differentiate between the warmth of experienced and novice users. An experienced user will adapt their sleep position, clothing and use of the hood, shoulder baffle etc to optimise the performance of the sleeping bag.

The French standard defined the following temperature values:

Comfort temperature: the inexperienced user will not feel discomfort, even localised, with the cold.

Limit of comfort temperature: the experienced user will be neither hot, nor cold. An inexperienced person can have a general feeling of discomfort.

Extreme temperature: an experienced user will feel a feeling of cold. For a user not tested, there is risk of hypothermia at the end of a few hours.

The method of the test is similar to that in ASTM F1720-96 above but the manikin is clothed in long underwear and socks and is laid on a foam mat. The Comfort Model defined in the French norm is similar to the one used in EN 13537 but the values for Comfort and Limit of Comfort are approx. 5 °C lower (colder) than those in EN 13537.

G 08-013 1994 was used by several brands including Lafuma, Lestra Sport and Vango and the French retailer Decathlon. All have now changed over to EN 13537.2002.

7. THELMA (SINTEF) MANIKIN TEST

By Bård Holand, Thelma

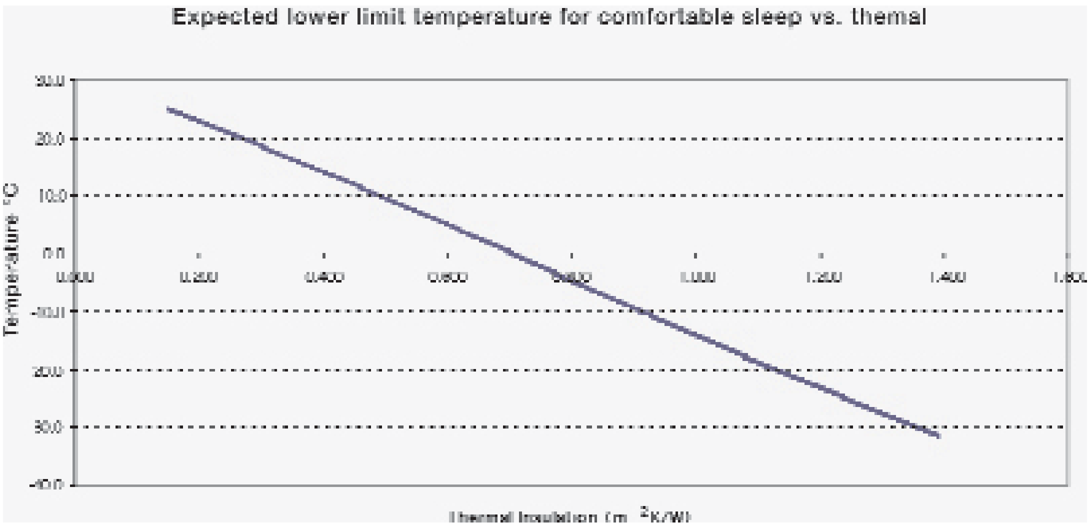
This test is important as it has been the commercial norm accepted within the Nordic markets. The test was used by Ajungilak and other Scandinavian brands to define their comfort ratings.

The lower comfort level is calculated in accordance with ISO Technical Report 11079: Evaluation of cold environments - determination of required clothing insulation - IREQ, and is defined as the temperature where the insulation of the sleeping bag will provide a neutral thermal state after 8 hours with a body metabolism of 55 W/m^2. This limit has been verified as acceptable based on human exposures (both male and female) under laboratory conditions (see 7.1).

Measuring the insulation value

The nude manikin is placed inside the actual sleeping bag (test sample) and placed on top of a 10mm mattress (standard used by the Norwegian Army), which again is lying on top of a foldable camping bed with metal springs. This set-up is placed inside a climatic chamber where the environmental parameters (temperature, wind and humidity) are well defined. The manikin is heated to a constant surface temperature (34°C), and when all readings are stable, heating power required keeping the temperature of the 20 different body segments stable is sampled for a period of 30 minutes. The average values are used to calculate the thermal insulation of the sleeping bag by means of a serial calculation model as defined by EN-13537.

Graph showing the relationship between measured thermal insulation of a sleeping bag, and expected lower temperature limit for comfortable sleep based on the Thelma model



Picture showing the test set-up with the manikin "Louise" being prepared for a test

7.1 SINTEF experiment to benchmark manikin with human trials

In 1997, human subjects performed a series of experiments in a climate chamber at SINTEF in order to evaluate the comfort model developed based on ISO Technical report 11079 as described in Chapter 7.

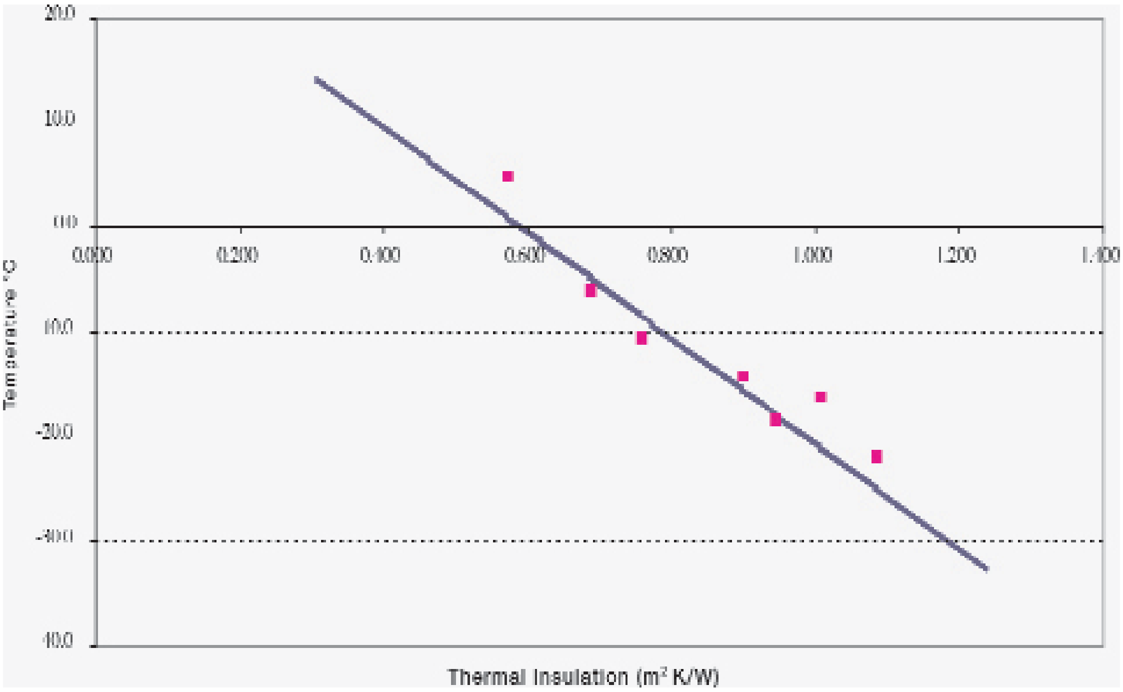
A number of sleeping bags (7) with different insulation values were selected for the evaluation. First a series of thermal manikin tests were performed in the climate chamber to determine the thermal insulation values for the test sleeping bags.

Next, using six men (age 28.2 ±7.8 years) and six women (age 24 ±2.4 years), a rather large number of tests were done where the test subjects slept over night in the climate chamber with the different bags under specified thermal conditions. A minimum of underwear was used. For temperatures above (warmer than) -15°C, a field mattress similar to the one shown in the picture in Chapter 7 was used, but for temperatures at and below -15°C, an additional foam mattress (thickness approx. 5cm) was used. In addition to that, a balaclava was used to add head (and face) protection for temperatures at -15°C and colder.

During the tests the subjects were monitored (core and skin temperatures), and in the morning they also answered a list of questions in order to determine their subjective thermal sensation during the night. All subjects that were not able to sleep due to cold aborted that test and did a new test with the same sleeping bag at a higher (warmer) temperature until their temperature limit for the actual sleeping bag was established.

In the figure below the average results for the 7 bags are plotted (as squares). The solid line represents the predicted comfort temperature versus thermal insulation based on the original comfort model. (Note that this line deviates slightly from the present comfort line presented in Chapter 7. The reason is partly that the insulation values used originally were calculated in a slightly different way (according to the former standard INSTA 355), and partly because later experience have shown that bags originally were rated a bit optimistic - especially around 0°C and warmer).

The values presented in the figure below for the 7 bags represent the average values for all 12 subjects. The statistical 95% confidential intervals (i.e. the interval that one may expect that 95% of a similar population will find acceptable) were approximately the average value ±1°C for bags warmer than -15°C. the intervals were slightly wider for the colder areas. There was a surprisingly small deviation between male and female. This may have to do with the selection of the female subjects.



The figure shows a comparison between human evaluations of 7 sleeping bags (squares) with known thermal insulation, and predicted comfort values (solid line) based on the comfort model.

8. EN 13537:2002 REQUIREMENTS FOR SLEEPING BAGS

8.1 What is EN 13537?

The European Norm

The European Standard EN 13537 is important in historical terms and legislative terms. It was the first system that was created by a panel of academics looking to create a super safe system as a basis for consumer claims and product liability cases. It is the first mandatory standard for the labelling of sleeping bags. The standard has important legal implications for brands, distributors and retailers selling sleeping bags in Europe. If sleeping bags are defined in the future as safety critical equipment by the EU, EN 13537 will be the product test within the PPE (Personal Protective Equipment) initiative.

- EN 13537:2002 Requirements for Sleeping Bags is a complete product standard which defines how to test, measure and label a sleeping bag.

- EN 13537 applies to all sleeping bags with the exception of sleeping bags for military use and sleeping bags for extreme temperatures.

The main impact of the standard is that it requires the temperature ratings to be determined through a manikin test and displayed according to particular rules. It also includes methods for defining the dimensions and required fabric tests related to sleeping bags. There are four documents relating to different parts of the requirements.

EN 13537:2002	Requirements for Sleeping Bags
EN 13538:2002- 1	Measurement of Sleeping Bags - Inner dimensions
EN 13538:2002- 2	Measurement of Sleeping Bags - Thickness
EN 13538:2002- 3	Measurement of Sleeping Bags - Compression volume

8.2 Which countries require EN 13537?

Members of CEN are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, The Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland, and United Kingdom.

In April 2002, European Standard EN 13537 was approved by CEN. This became the official standard in Germany in November 2002 and in France in January 2003. It will be ratified by most member countries of the CEN by the end of 2003.

8.3 What is the legal position over EN 13537?

The legal position for brands, retailers and distributors is very important. It is beyond the scope of this publication to give comprehensive legal advice that applies to all countries. These notes are included to highlight the main issues:

In theory, a product that communicates the temperature ratings to anything other than EN 13537 is misleading the public. Hence legal action could be taken to remove it from the whole European market. Such dramatic action is unlikely until 2005 as the courts would probably recognise that manufacturers and retailers need time to adopt the new standard and clear old stocks. It is possible to supply sleeping bags without a recommended temperature rating but if any temperature rating is used it must conform to EN 13537. Legal action would come under the national laws governing Trading Standards or Advertising Standards.

With branded goods, if the brand has an office in one of the member countries, then the responsibility rests with the brand. If the brand is from outside Europe and has a distributor in Europe, the responsibility lies with the distributor. If neither the distributor nor the brand is based in Europe, the retailer takes all of the responsibility. With retail own brand products, the retailer bears the responsibility.

A Trading Standards Officer in England advised that the most important point is that manufacturers demonstrate that they have taken all reasonable steps to ensure that their products perform in accordance with their claims. He advised that the actual test method is a secondary consideration, but that it should be a recognised and reproducible standard.

8.4 Four Values for Temperature

EN 13537 produces four temperature results - upper limit, comfort, lower limit and extreme.

- The EN 13537 **Upper Limit** is based on a standard man as the highest temperature without sweating to have a comfortable nights sleep.
- The EN 13537 **Comfort rating** is based on a standard woman having a comfortable nights sleep.
- The EN 13537 **Lower Limit** is based on a standard man as the lowest temperature to have a comfortable nights sleep.
- The EN 13537 **Extreme rating** is a survival rating for a standard woman.

8.5 Is EN 13537 a good test?

A good standard should:
- Be reproducible in several test houses
- Be supported by scientists from several different international test institutes
- Produce results that are comparable with manufacturers established norms
- Produce results which match the experiences of expert users
- Produce results which match consumer perceptions.
- Be affordable for the manufacturers
- Add value to the consumers purchase decision

Is it reproducible?
The test is available at ITFH France, Hohenstein Germany and Thelma in Norway and will soon also be available at several other institutes. The test requires initial calibration of the manikin against a set of reference sleeping bags from ITFH Lyon. Calibration procedures mean that tests in different institutions should not deviate by more than ±5%.

Do the scientists agree with it?
Overall most scientists agree with the test. It can accurately measure sleeping bags over a wide range of temperatures and is sensitive enough to measure differences in sleeping bag shapes, zip baffles and hoods

There has been some criticism of the test parameters by scientists. However, to make any standard that is affordable and reproducible in laboratories world-wide, some values have to be fixed.

EN 13537 does take in sweating but only as a simplified calculated value. Sweating can reduce the insulation, particularly at low temperatures. However, very few institutes have or could afford a sweating humanoid manikin and it would be exceptionally difficult to calibrate. The test is already expensive. A sweating manikin test would probably double the cost per test.

There has also been criticism that the clothing defined in the test does not match consumer practice. Consumers generally wear virtually no clothing when it is hot and add more clothes when sleeping in cold environments. Similarly, there has been criticism that the sleeping mat used in EN 13537 is too thick. However, the insulative properties of sleeping mat and the clothing must be fixed in order to make the test reproducible in different test houses. It would become impossible to compare the results between sleeping bags if different sleeping mats and clothing were specified for different temperature ranges.

Does it match commercial practice?
EN 13537 does not match commercial practice for sleeping bag brands. In general, the values for Maximum temperature and Extreme temperatures are similar. However, the EN 13537 values for Comfort are quite different. Part of the problem is the definition of terms of the lower limit and comfort temperatures. The Comfort Temperature in EN 13537 is set on a completely different benchmark than the industry practice as it is based on women. The comparable figure to use is the Lower Limit of Comfort which is based on a standard man.

Decathlon publishes EN 13537 data for all sleeping bags in its 2003 catalogues. In May 2003, Thelma made a test of six non EN 13537 sleeping bags comparing the published lower limit of comfort values with the new EN 13537 standard.

The EN values were always higher by 4 to 9 °C. By this point several French and German brands and one Scottish brand had already began to display values to EN 13537. The average differences for the remaining brands were as follows:

Scandinavian	4 to 5 °C
German	4 to 6 °C
British	5 to 7 °C
American	8 to 12 °C

Does it match consumer experience?
Before EN 13537, outdoor shop staff customarily advised consumers to buy a sleeping bag that is 5 °C warmer than the label suggests. Therefore, it is logical to argue that the new norm reflects the actual consumer needs much better than previous commercial practice.

From comments received from consumers, it appears that the EN 13537 values relate well to the experience of ordinary consumers.

8.6 EN 13537 and Military Users

In the introduction, it states that EN13537 does not apply to military sleeping bags. There are two principle reasons that the EN 13537 temperature test does not apply to military users. Firstly, each army specifies clothing and sleep mat which are different to those defined in EN 13537. Secondly the user population is mainly young fit men so the heat output of the sleeper will be much higher than the 80-W specified in the EN 13537 test.

It is theoretically possible for an army to specify a customised test based on EN 13537 that is modified to use the exact garments and sleep mats issued to the soldiers and to use a higher value for heat output from the sleeper. However, the data from a standard EN 13537 test is still a valid comparison between sleeping bags and some military buyers request it.

8.7 EN 13537 and Extreme Low Temperatures

EN 13537 does not apply to sleeping bags for extreme low temperature use. The thermal resistance tables in EN 13537 suggest that sleeping bags which claim comfortable sleep below - 24 °C would be outside the standard.

The principle reason for exclusion of these temperature ranges is that the sleep mat and clothing used are very different to those defined in EN 13537. Defining such a test would be difficult as there are different clothing conventions for polar travellers and mountaineers. For example, polar explorers often use vapour barrier liners and mountaineers often sleep with a full down suit inside the sleeping bag. Secondary reasons are the effects of sweat and respiration. Heat lost through respiration becomes an important factor in very cold conditions. Also, moisture from respiration and sweat reduces the effectiveness of the insulation.

It is theoretically possible to create a customised test based on EN 13537 that is modified to use the exact garments and sleep mats. It is also possible to use a sweating manikin and an exceptionally cold climate chamber. Both of these would be expensive to test and difficult to repeat in different laboratories. However, the data from a standard EN 13537 test is still a valid comparison between sleeping bags of different designs and from different manufacturers.

8.8 Cost implications of EN 13537

EN 13537 is a very costly test and therefore not without controversy. Some commentators view it as an obscene tax on the industry.

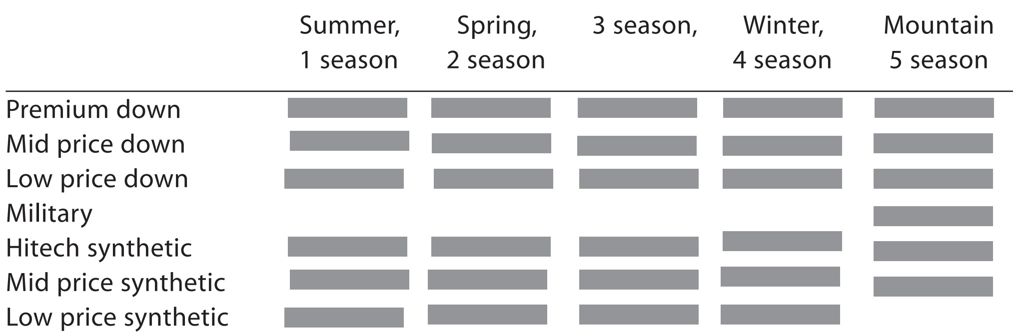
How much does it all cost?
A full set costs of documents approx 200 to 340, depending on language.
A full test to EN 13537 costs 1500 per sleeping bag.
The temperature test part only can be done for 600 at ITFH Lyon and Thelma.

Calculation of Cost Effect per Product

When you compare the cost of testing with the typical volume / price relationship for an individual model it is equivalent to 6% of the manufacturing cost. It is very unlikely that brands will be able to pass this on as price increases. In these times of thin manufacturer margins, the last thing the industry needs is a 6% increase in costs. If you add in the marketing costs for amending catalogues, hang-tags, data sheets etc, the picture is even worse.

Calculation of Cost Effect per Brand

Most sleeping bag brands have a small number of basic designs each available in several temperature ratings. The illustration shows a typical brand structure (ignoring length and zip variants).



The brand above has 30 designs that would need testing to EN 13537. At 1500 per test, this is 45,000. Marketing and print costs to alter data labels, catalogues, hang-tags, Point of Sale etc will cost at least the same amount as the testing. So the brand faces a bill for 90,000.

Norms

Is the cost justifiable?
If you examine the published accounts of outdoor companies, you will see that a 6% net profit over the past few years has been a success story. We have already shown above that this cost cannot be passed to the retailer. A quick calculation shows that this extra cost of 90,000 eliminates all of the profit on the first 1,500,000 of sales.

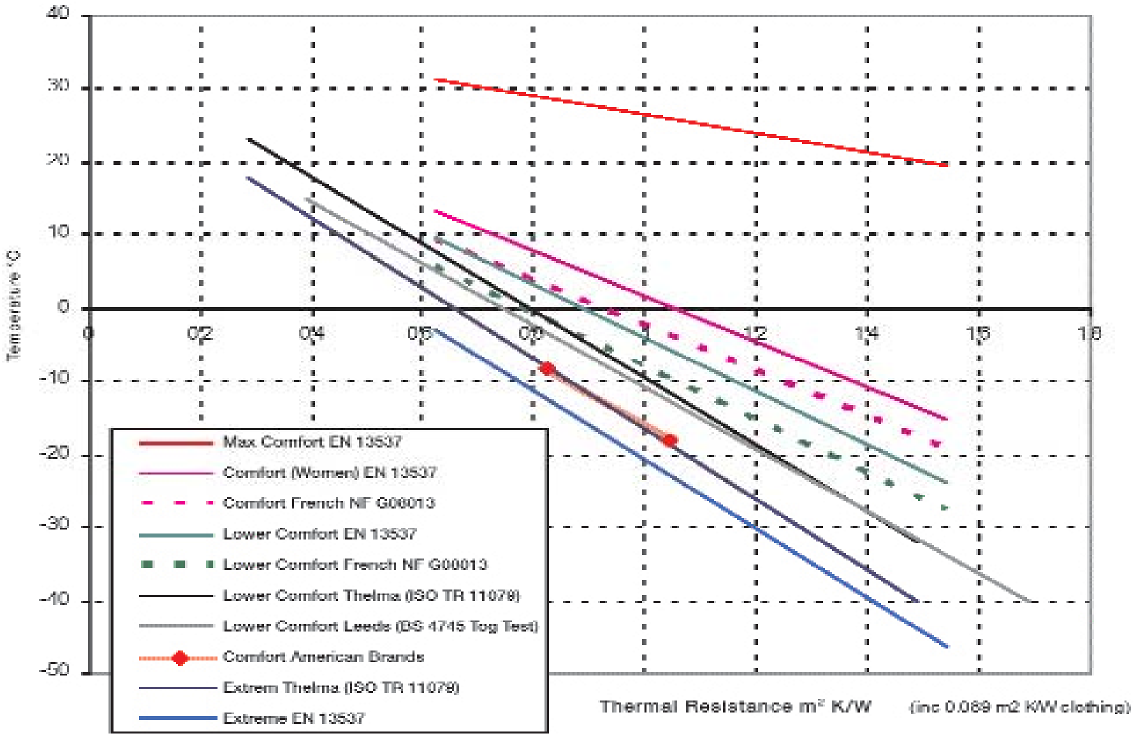
Furthermore, very few companies are achieving a turnover in excess of 1.5 million from sleeping bags alone. For smaller brands, they will be faced with no choice but to reduce their product offer or in some cases drop sleeping bags altogether. Similarly retailers will have to think twice about own brand products as the economics will change significantly.

Product Liability
When you examine the case for and against EN 13537, you cannot help but see a parallel with the automobile industry. The industry initially objected to safety standards which demanded improvements to seatbelts, lights and airbags. Consumers expect safe and clearly labelled products. 90,000 appears a lot for a brand but it is very little in comparison with the cost of a product liability claim.

Even though the manufacturers object to the extra cost, there are clear benefits for the consumer. EN 13537 forces more professional behaviour from suppliers. It is no longer acceptable to make a few sleeping bags and guess a temperature rating. The whole industry has suffered from unrealistic values and over hyped claims.

EN 13537 gives a safe and comparable standard that consumers can trust.

9. COMPARISSONS BETWEEN STANDARDS



In previous chapters, we have shown that there are several comfort models that relate the thermal resistance of the sleeping bag to the temperatures quoted. Where there are clear published relationships, it is possible to plot a graph showing the temperature recommendations for a given thermal resistance. As the graph shows, a sleeping bag with a thermal resistance of 1.0 m^2 K / W (10 Tog or 6.5 Clo), gives the following values.

Note: To make a valid comparison, the values of the Leeds model and Thelma model have been adjusted to match the 0.089m^2 K/W of clothing specified in EN 13537

Comfort Temperatures	
EN 13537 Comfort (for Standard Woman)	+ 2 °C
French Standard (NF G08-013)	- 3 °C
EN 13537 Limit of Comfort (for Standard Man)	- 4 °C
Thelma Comfort Model (based on ISO TR 11079)	-10 °C
Leeds Comfort Model (based on BS 4745 (Tog Test)	-11 °C
American manufacturer's data	-16 °C

Note: American Manufacturer's data - We have not found a defined relationship that is widely used by American brands. The data points shown are the manufacturers published values for two popular American products that have been tested to EN 13537.

Extreme Temperatures	
Thelma Comfort Model (based on ISO TR 11079)	-16 °C
EN 13537 Extreme Temperature (for Standard Woman)	-20 °C

10. PRACTICAL ADVICE

10.1 Advice for Retail Buyers and Journalists

Expected Values

As EN 13537 is a standard and repeatable test, it is quite easy to see when the values quoted by manufacturers are reasonable. The following tables show typical weights of sleeping bags (including stuff sack) for different temperature ratings to EN 13537. If the values quoted are significantly different then it is good advice to ask to see the test certificate.

		Summer	3 Season	Winter
Thermal resistance	m^2 K/W	0.62	0.9	1.3
EN 13537 Comfort (Women)	EN 13537	13 °C	5 °C	-8 °C
Lower limit of comfort (Men)	EN 13537	10 °C	0 °C	-15 °C
Extreme	EN 13537	-3 °C	-15 °C	-35 °C

High performance down mummy bag	Grams	500g	950g	1600g
Cheap down mummy bay	Grams	1000g	1700g	2800g
High performance synthetic mummy	Grams	850g	1550g	2450g
Cheaper synthetic mummy	Grams	1100g	1900g	2950g
Cheaper rectangular synthetic	Grams	1750g	3000g	

Advice to retailer buyers

In general, retailers appear to welcome a fixed and comparable standard. From our research, more and more buyers will ask for EN 13537 values and also to see the test certificates. Decathlon was the first retailer to demand EN 13537 certification for summer 2003. Decathlon has chosen not to display the EN 13537 extreme temperature ratings to ensure that consumers do not overestimate the warmth of the sleeping bag.

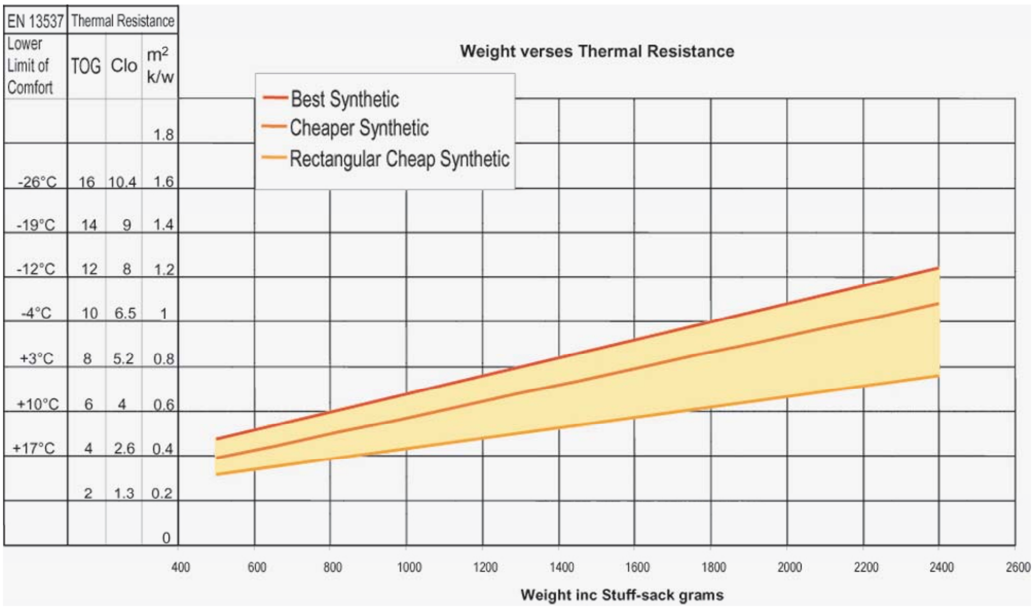
Generally, retailers will be expected to comply with EN 13537 temperature labelling two years after it has been ratified in their country. For retailers in France and Germany, it is therefore important to have all products in store labelled to EN 13537 by December 2004. For retailers in other countries it is advisable to check when EN 13537 was ratified for their country. The position of retail own brand products is very important. The retailer takes the legal responsibility for the product and must ensure that the product is labelled according to the standard.

Advice to Journalists

Journalists should take steps to ensure that all test models in magazines have temperature values quoted to EN 13537. The best possible practice would be to ask the brands for a copy of the EN 13537 test results for any product in a magazine review.

10.2 Reference Chart for Retail Buyers and Journalists

A quick check is to weigh the sleeping bag with the stuff-sack and check it against the graph. If the values are outside the expected range - ask for the certificate.



10.3 PRACTICAL ADVICE FOR CONSUMERS

Understand the Temperature Ratings.

The EN 13537 Comfort rating is based on a standard woman having a comfortable nights sleep.

The EN 13537 Lower Limit is based on a standard man as the lowest temperature to have a comfortable nights sleep.

The EN 13537 Extreme rating is a survival rating for a standard man. This must not be used by normal consumers as an influence on the planning of a purchase or selection for a trip.

Non EN 13537 ratings - Most of the sleeping bag ratings before EN 13537 were based on fit well conditioned young men and created from studies on soldiers, outdoor instructors and mountaineers. Therefore, a much greater margin of safety needs to be applied.

Be realistic about your body and your physical condition.

Conditioning EN 13537 sets a much more conservative comfort level than previous systems and is based on the normal European consumer. However, most westernised people live in centrally heated houses, work in air conditioned offices and drive everywhere. This lifestyle reduces the bodies conditioning against cold. If a sedentary person goes on a strenuous trip into the wilderness or high mountains, they will become fatigued. Unfit people feel the cold more than fit people. Thin people feel the cold more than fat people.

Age Young well nourished men produce more body heat than older people. Children, especially small children do not have the same natural heat controls as adults and need to be carefully monitored.

Sex Women are generally colder than men. In EN 13537 the comfort temperature for a standard woman is approx 5 °C warmer than the standard man.

Prepare properly for your tour.

Select your sleeping bag with enough safety margins for the trip you are planning.
Invest in a Good Sleeping Mat A good sleeping mat will insulate you from the ground and provide comfortable padding. If you do not use a mat, you will lose a lot of heat through conduction.

Invest in a Good Tent or Bivi Bag - A tent or bivi bag has two functions. One it protects from the rain and two it protects from the wind. It is important that the tent is sealed from the weather. If the sleepier is directly exposed to the wind this will considerably increase convection losses.

The Weather - Over any period of five days, the weather will typically change by plus or minus 5 °C and in storm conditions; the changes can be much larger. Also, if it rains or snows, you will become wet, tired and cold. Getting into a sleeping bag after backpacking in the pouring rain will reduce the insulation as the sleeping bag is damp and you will be cold. Check the long range weather forecast.

Altitude - The night time temperature at valley level may be warm but high in the mountains it will be much colder. As a rule of thumb, temperature falls by 5 °C for every 1000m of altitude. Also, the weather in the mountains is more extreme than in the valleys.

Distance from Shelter - If you are planning a trip in the wilderness or the high mountains make sure that you have the skills, knowledge and equipment appropriate to the conditions that you may encounter. Make sure you know where to find and the distance to the nearest shelter.

During Your Expedition

Even the best sleeping bag does not compensate for the following precautions:

Take Extra Clothing - Even in summer, it is advisable to carry expedition weight underwear, particularly a long sleeved thermal top and full length leggings.

Mammut offers the right underwear for all kind of conditions. A full set weighs less than 400 grams but can be used night and day. These can be worn under your normal clothing if it becomes cold and you can sleep in them on cold nights.

Longsleeve all-year

Pants long all-yeas

If you are going into sub-zero conditions also take a balaclava and bivouac socks. It is easy to upgrade the warmth of the sleeping bag by wearing expedition underwear, a balaclava and socks.

Eat Properly If you do not eat enough food, your body will produce less heat and you will feel colder. If you are backpacking, you will use a lot of energy and must replace it.

Drink Plenty - but avoid Alcohol. Dehydration also reduces the body's ability to produce heat. Drinking is very important. It is best to drink water, coffee, tea or soft drinks. Cocoa or hot chocolate as a late night drink are much better for you than alcohol. Alcohol may initially make you feel warmer but as it wears off you will feel the cold even more.

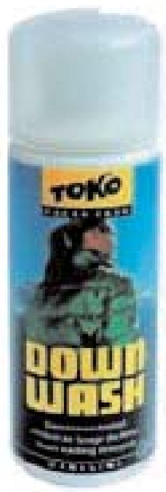
Keep your gear dry - Wet clothing and sleeping bags (especially down) have less insulation than dry ones. Try to keep spare clothing and sleeping bags dry. Keep them inside a plastic bag in the backpack. Try to keep rain, snow and mud out of the tent. If you can, keep the sleeping bag away from the walls of the tent. Use the ventilation flaps on the tent to avoid condensation. Whenever you have the chance air-dry the sleeping bag - for example on top of your tent in the morning.

Wear that extra clothing If you brought it, use it. If you do feel cold, increase the warmth of the sleeping bag by wearing expedition underwear, a balaclava and socks.**Special Care Advice for Down and Synthetic Sleeping Bags**

Down sleeping bags are affected by dampness. This comes from humidity in the air, condensation on the walls of the tent or your own sweat and respiration. Whenever you have the chance air-dry the sleeping bag - for example on top of your tent. Many down sleeping bags have black fabric on one side so that they dry quickly in sunlight. Down will get smelly if it is left in a damp state. Do not store a down sleeping bag in its fully compressed state as this will damage the down clusters. Store a down sleeping bag in dry conditions either by hanging in a wardrobe or using a large cotton storage sack. Wash the sleeping bag occasionally using a special down wash product. Follow the wash care instructions.

Synthetic sleeping bags will lose insulation power each time they are washed. With high quality products, the loss is very small. Some cheap resin bonded products will loose much of their warmth within 10 washes.
Synthetic sleeping bags will need washing occasionally. For best results use a special sleeping bag washing product. You can use a sleeping bag liner which can be washed frequently so that you need to wash the whole bag less often.

Use a special wash product
for sleeping bags



11. ADDRESSES

Mammut

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