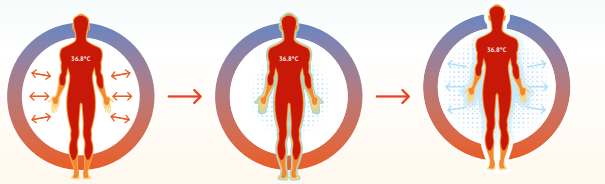
WHAT IS HOT/COLD? TEST METHODS

IN VERY SIMPLE TERMS:
HEAT IS ENERGY AND **COOL IS THE ABSENCE OF ENERGY.**

The human body generates heat and is constantly trying to regulate the core temperature in the range between 36.5–37.5°C (see Focus Topic „Thermal Technologies“, November 2017). Heat can be generated directly from the human metabolism (= metabolic heat) and by the effect of environmental conditions on the human body (like air temperature, radiation, humidity, wind). When more heat is generated, e.g. from sports activity, the body reacts by producing sweat to regulate temperature and to cool down.

THE STAGES OF COOLING



1 Generation and/or Absorption of Heat

2 Sweating Starts/ Moisture Transport

3 Evaporation of Perspiration (Physiological Cooling)

One test method for determining the moisture transfer of clothing systems and textile insulation systems is the sweating **Torso** at Empa. The Torso allows the degree of thermal insulation of surface materials as well as the cooling effect of perspiration to be determined. In this way, the thermal characteristics of single and multiple layer textiles can be studied and optimized for the corresponding application.

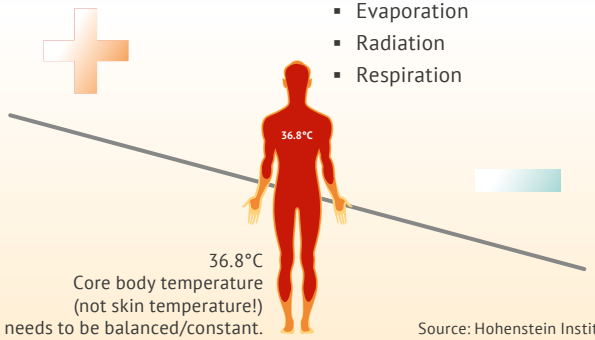
WATson is a measuring device developed at Hohenstein and based on the principle of physio-thermal regulation: The physical cooling performance of a textile can be quantified under actual use conditions. WATson enables fast efficient testing of the „cooling effect“ of textile fabrics early in the development process without the need for cost intensive wearer trials in a climate chamber so that fabrics can be optimized and compliance with quality standards is ensured.

It is to be considered that with all tests, the cooling effect on the skin depends on many factors and is perceived differently by each individual.

HOW DOES COOLING WORK?

For cooling purposes, the "Minus" (factors leading to heat loss) needs to outweigh the "Plus" (factors generating heat). The factors are:

HEAT (PLUS)	<	COLD (MINUS)
▪ Environmental condition: Heat ▪ Metabolism: Gain heat (sports activity or cold shivers = motion = heat)		▪ Environmental condition: Cold ▪ Metabolism: Lose heat cool (cooling from sweating and evaporation) ▪ Absorption ▪ Conduction ▪ Convection ▪ Evaporation ▪ Radiation ▪ Respiration



36.8°C
Core body temperature
(not skin temperature!)
needs to be balanced/constant.

Source: Hohenstein Institute

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COOLING TECHNOLOGIES

CONVECTION

Warm air or water vapor is transported within or out of the clothing system. This type of transport can also be forced, e.g. by the motions of the wearer.

CONDUCTION OR DIFFUSION

Heat always flows only in the direction of the lower temperature – from warm to cold – unless the heat transport is prevented, e.g. by the insulating air.

Ambient temperature relationship to the body temperature: Body heat > ambient temperature	**Ambient temperature relationship to the body temperature:** Body heat = ambient temperature	**Ambient temperature relationship to the body temperature:** Body heat < ambient temperature
Effect: Heat loss to the external climate	**Effect:** No heat exchange	**Effect:** Heat to the person
Cooling for humans? Yes, until cooled down/ freezing	**Cooling for humans?** No, as it is the optimal comfort zone for people	**Cooling for humans?** No, additional heating

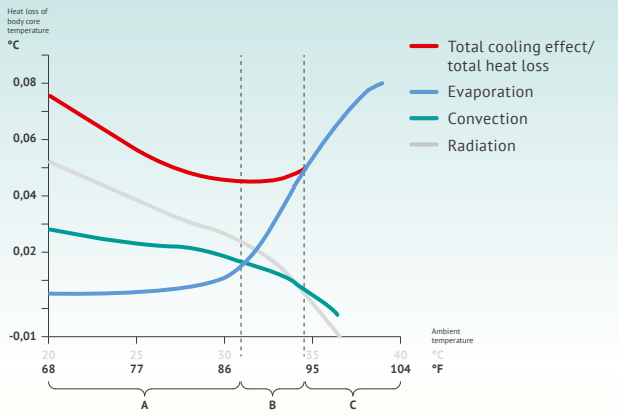
EVAPORATION/VAPORIZATION

Liquids are transformed through the absorption of energy into the aggregate gaseous state, for example, perspiration into water vapor. The greater the contact area of the liquid on the heat source, the more sweat can evaporate, the required energy is drawn from the body and cooling is achieved. In accordance with our human physiology and physics, evaporating sweat is the best and most effective method to draw heat out from the body (2.4 kJ/g at skin temperature, Hohenstein Institute) – and that is why people sweat!

(THERMAL) RADIATION

Heat is thermal energy in the form of electromagnetic waves. The wavelength can vary. The shorter the wavelength, the more energy it has (Joule) – thermal radiation may extend from short wavelengths (NIR) over mid-range (MIR) to long wavelengths (FIR). The strength of this radiation/the wavelength is variable.

WHAT IS THE BEST WAY TO KEEP THE BODY COOL?



Source: Hohenstein Institute

The measurement values chart above shows:

A For ambient temperatures of ca. 20–31°C, radiation is the strongest cooling factor.
→ Ensure the use of fabrics that reflect visible light (MIR, not UV light) and do not heat up.

B For ambient temperatures of ca. 31–35°C, a combination of radiation, convection, and evaporation produces the greatest cooling effect.
→ Ensure the use of fabrics that reflect visible light (MIR, not UV light) and do not heat up.
→ Sweat in the form of water vapor passes through the textile thanks to ventilation slots and mesh.
→ Rapid and wide distribution of sweat close to the skin surface creates more area for evaporation.

C Above an ambient temperature of 35°C, evaporation is really the only relevant factor.
→ Rapid and wide distribution of sweat close to the skin surface creates more area for evaporation.
The cooling effect of max. 0.08°C heat loss refers to the core body temperature – not the skin surface temperature!

WHAT IS IMPORTANT?

- Physiologic/physical cooling effects are **measurable and should be measured**. The key is to define how and what to measure. Figures cannot be compared unless tested to the same standard. That is why the fabrics at the Jury's Pick Table are not ranked – the measuring methods are not comparable.
  A value like 0.05°C can be the change in body core temperature or the skin temperature. A loss of 0.05°C body core temperature is quite a bit, while 0.05°C skin temperature is nothing. **Always ask what (DIN) ISO or test method was used for the testing.**
- PCMs are tested according to DIN 16 806-1 which measures the heat storage and release capacity, so not the cooling effect in -/+xy°C. The idea behind **PCMs is rather to keep the body temperature stable** by absorbing and remitting heat, so avoiding over-heating and sweat production.
- **The haptic** of the fabric might be misleading: The ambient and body temperature when sourcing the fabric will be different from when the finished garment is actually used. It is neccessary to know in which environment the use is intended, e.g. the ambient temperature in which the cooling needs to be achieved. The technology(ies) similar to the graphic should be intelligently chosen and combined.
- For a short period of several minutes, **sensory cooling (triggering of the skin receptors)** or the Cool Touch feel may be experienced, but this does not lead to long term intensive heat dissipation and is not suited for metabolic activities (for the body to generate heat).
- Above an ambient temperature of **35°C, evaporation is most effective**, but requires perspiration on the skin.
- **The weight of a fabric** influences its cooling intensity and duration:
  Light fabric → shorter but more intensive cooling
  Heavy fabric → longer but less intensive cooling
- **Be aware:** The performance of tested fabrics can be **affected by washing**, especially when the cooling effect is based on a finish applied to the fabric's surface (not in the fibre).
- Next to the measurement values, the comfort of the wearer needs to be considered as well. As always, **people experience sensory perception and psychological interpretation differently**. What is measured in the lab or what is felt/thought by one, may not be the same for another person. Therefore, the recommendation for clothing is: do both! Test in the lab and on people under controlled and realistic conditions.
- **Post-exercise chill effect:** A soon as the body cools down, it stops perspiring and no new sweat is produced. However, although cooling is no longer necessary, there may still be some sweat that continues cooling through evaporation. The body chills down to the corresponding outside temperature if no other technology is present (e.g. an exothermic effect or PCM) or, the person takes a shower, dries off and puts on appropriately warm and dry clothes.