THERMAL PHYSIOLOGICAL COMFORT

From Wikipedia:

Comfort is a purely subjective feeling perceived by the user, in a working environment or specific service conditions, and indicates the "level of wellbeing" perceived.

According to this generally accepted definition, the term **comfort** is associated with wellbeing, regarded as the range of pleasant feelings resulting from stimuli that are internal or external to the body. The degree or level of **comfort** should therefore be considered a highly subjective condition that is impossible to measure or compare.

In order to find an overall definition of **comfort**, we need to include an aspect of objectivity: we need to address the problem from a physical and/or physiological viewpoint and analyse what objectively happens to our body when it comes into contact with **clothing items**, home textile products or various kinds of accessories.

Comfort is therefore the level of wellbeing offered by a product, determined by the **feeling perceived when it is worn.**

Comfort assessment is based on a typically sensorial approach and is strictly affected by a number of identified and measurable variables: type of model; the ability to adapt to the user's morphology and not to change over time and under different conditions; the ability to respond to the user's needs in terms of size; intrinsic engineering to respond to a number of performance needs; aesthetics; the ability to avoid physiological inconveniences such as irritations, dermatitis, thermal stress, excessive perspiration, proliferation of bacteria and allergies.

Thermal physiological comfort

Thermal physiological comfort is the prime indicator that helps us move from the concept of feeling to an objective assessment: **Comfort** and **Thermal physiological properties** associated with **comfort**.

Before speaking about **thermal physiological comfort** we need to understand the meaning of thermal **comfort**, that is, our mental and physical satisfaction towards the thermal environment. Our body must maintain a condition of thermal balance as much as possible: the metabolic heat generated by the body, added to that generated by external sources must correspond to an equivalent loss of heat.

If the heat gained and the heat lost are not in balance, our body temperature will decrease or rise, leading to lower levels of **comfort**. As a result, all the parameters that influence heat exchange between the individual and the environment must compensate the feelings of heat or cold perceived by the individual.

There are two types of parameters that need to be taken into consideration:

- Environmental or objective:
    - Temperature of ambient air (convective heat transfer)
    - Average radiant temperature (radiant heat transfer)
    - Air speed (convective heat transfer)
    - Air humidity (body's evaporative heat transfer)

- Individual or subjective:
    - Metabolic expenditure related to the activity carried out
    - Conductive and evaporative thermal resistance of clothing

The passage from the concept of **comfort** to **thermal physiological comfort** is reached based on three fundamental elements:

1. exercise by the human body;
2. the external environment;
3. the features of the clothes we are wearing.

The subtle connection between these three variables is the ability of any product, whether an **item of clothing**, accessory or padded blanket, to best perform three distinct functions:

- Thermal insulation
- Barrier to vapour transpiration
- Behavioural mechanism of **thermal regulation**.

The following measurable quantities need to be considered:

RCT (Thermal Resistance Coefficient) – determined using Skin Model lab instrumental analysis UNI EN ISO 31092:1996 and ASTM F1868)

RET (Evaporative Resistance Coefficient) – determined using Skin Model lab instrumental analysis UNI EN ISO 31092:1996 and ASTM F1868

https://t.silk.bio/news/thermal-padding-clothing/

The lab analysis that is best able to assess the **thermal physiological comfort index** and the above variables is the “Sweating guarded hot plate method” or, more commonly, Skin Model:

- The Skin Model measures **RCT** and **RET** expressed in m2K/W and m2Pa/W, respectively.

- The measurement must be taken in an environment in which relative humidity and temperature can be checked..

- Measurement conditions: RCT – Climate chamber at 20°C±0.1°C and 65%±3% UR

  RET – Climate chamber at 35°C ±0.1°C and 40%±3% UR
  Plate: 35°C±0.1°C
  Air speed 1m/s±0.5m/s
  At least 12h sample conditioning under measurement conditions

- **RCT** - The sample is placed on an electrically heated plate and air is forced to flow parallel to its surface. To determine thermal resistance, the heat flux through the sample is measured when steady state has been reached (almost equilibrium state). The value of RCT is obtained by subtracting from the value obtained the thermal resistance of the plate on which the sample rests and the relative layer of air.

- **RET** - the sample is placed on an electrically heated porous plate and covered by a membrane that is permeable to vapour but impermeable to liquid water. No liquid must come into contact with the sample.

The heat flux required to keep the plate at a constant temperature is in practice a measure of the water evaporation flux and allows us to find the evaporative resistance value. The RET value is obtained by subtracting from the obtained value the evaporative resistance of the plate on which the sample rests and the relative layer of air.

Standard UNI 31092 defines:

- **Thermal resistance RCT:** the difference in temperature between the two faces of the material, divided by the heat flux per unit area in the direction of the gradient.

  The dry heat flux may consist of one or more conductive, convective and radiant components. Thermal resistance is a specific quantity of textiles and composites which determines the flux of dry heat on a given area when a temperature gradient is applied that is stable over time.

- **Water vapour resistance RET**: the difference in water vapour pressure between the two faces of the material, divided by the evaporation heat flux per unit area in the direction of the gradient.

  Evaporation heat flux may consist of both diffusive and convective components. Water vapour resistance is a specific quantity of textiles and composites which determines the latent evaporation heat flux on a given area when a water vapour pressure gradient is applied that is stable over time.

Values and meaning attributable to the different variables:

RCT high – material with low conductivity
RET high – material with low breathability
Wd = Water vapour permeability - expressed in g/(m2hPa) = 1/(Ret x ΦTm) with ΦTm= latent heat of water evaporation at measurement temperature.

Imt = Water vapour permeability index = (**RCT/RET**)xS with S=60Pa/K

Imt is a pure number with a value between 0 and 1.
A material that has a value of 0 is totally impermeable to water vapour. A material that has an index equal to 1 has the thermal and evaporative resistance of a layer of air having equal thickness.

Imt is the parameter that more than any other expresses the coefficient of **thermal physiological comfort.**

T.Silk® has a very high **water vapour permeability index (IMT)** close to 1.