THE PHYSIOLOGICAL IMPACT OF SORPTION HEAT IN HYGROSCOPIC CLOTHING

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The nature of many textile fibres is hygroscopic as their content of water depends on the relative humidity (RH) of the ambient air. During absorption heat is generated and during desorption heat is required. Especially in wool the transient sorption heat changes are of a magnitude that garments made of this natural fibre are often attributed exceptional buffering qualities by people who must frequently shift between places with dry and humid air respectively. For various reasons it has proved difficult to establish the virtually perceived effect of such transient conditions. One reason being that less than half of the generated heat is expected to affect the body.

In a recently published study (1) the present situation was reviewed and the result of experiments with mittens was reported. The authors were fully aware of the difficulties in the use of hands to perceive warmth. At about the same time a comprehensive study of the impact of air humidity on thermal comfort (2) was finished The design of a number of the experiments performed was made so that the influence of the textile fibres used could be brought into focus. The objective of the present study was thus to identify the sorption heat effects in hygroscopic clothing during certain air humidity transients and to investigate their physiological impact.

The experimental work induded use of two adjacent climate chambers, one with 20% RH and the other with 80% RH, both maintained at the same temperature. Also a thermal manikin and a group of twelve college-age male subjects of a size corresponding to the manikin were involved. For experiments in both cases dothing ensembles with long, tight-fitting sleeves and legs made of wool or the practically non-hygroscopic polyester fibre were applied. The oven-dry weight of each ensemble was approx. 1500 g and the insulation value approx. 1.0 do (equivalent to that of indoor winter clothing).

The experiments involved a quick shift from one chamber to the other with a resting period of 90 minutes in both chambers to attain apparent steady-state conditions. The climatic changes were in either direction and at the outset of the preparation period clothes were put on which had been brought into equilibrium with the actual climatic conditions. Experiments in the nude were also performed as the human skin was expected to respond to humidity transients. As a control measure in each experiment the mean skin temperature and the deep body temperature were measured on two of the subjects. During their stay in the chambers the subjects were asked to give thermal sensation votes according to a scale from -3 (cold) to +3 (hot) units. The voting was a first impression vote at t=O after the stepchange followed by votes at I-minute intervals for 5 minutes and 5-minute intervals for the remaining period up to 90 minutes.

The separate manikin experiments provided physical information about the progress and size of the heat changes and their effective impact on the body. In figure 1 an absorption period for wool is depicted. Desorption is slightly different because of hysteresis in the exchange of water. Calculation indicates that about 40% of the total heat changes will affect the body, which confirms original findings. The effect of polyester dothing was less than 5% of that of wool and dissipated within 20 minutes.

Some results of the subject experiments based on mean votes are depicted in figure 2. Common features of the two contrasting materials are strong immediate responses to the step-change with that of the down-step considerably larger than that of the up-step. Specific features include a return within 20 minutes to an apparent steady-state for polyester while wool is still out of balance at the end of the period. The graphs are derived from a set of experiments, the results of which were submitted to a factorial analysis with 3 factors at 2-levels RH-change, temperature and the materials used. The model proved significant for all points tested on the time axis (p > 0,01%). This was, of course, also the case for the direction of the RH-step. The interaction between RH and material is highly significant except for t=o and showed clearly an active effect of wool.

At t=o a complicated process is presumably initiated comprising cutaneous perception of the climate change at accessible skin surfaces, sorption heat changes of the skin and beginning transfer of textile heat changes. It adds up to an instant jump followed quickly by an apparently decreasing effect which is soon superseded by the textile material effect, if any, or an apparent steady-state. This interpretation may be supported by the shape of the initial part of the manikin's heat loss graph as the manikin has neither skin nor cutaneous receptors. A visual comparison of the plots of skin temperature changes with the voting graphs makes similar patterns visible, with an initial delay governed by the skin reaction rather than by the thermal sensation. The instant jump in the polyester case was sizable, even overshooting the apparent steady-state *in both* directions of RH-change. In the wool case the jumps at both directions were markedly smaller. This may be explained by the hygroscopic property which wodd cause **a** delay of the impact on the body **of** climate changes.

In order to estimate the magnitude of the wool effect it must be separated from the general effect of the humidity change *of* the **air.** However, this **seems** not possible *in* the present case. **Both** skin temperature and deep body temperature measurements indicate **that** steady-state *of* **the subjects** was not attained. **A** provisional approach to circumvent this problem may be based *on* other experiments where the climatic conditions were modelled so that the **themal** sensations before and *after* the applied step-changes were of the same magnitude. The deviations from the **above** mentioned study were **small.** In principle the **only** important parameter left would then be the hygroscopic effect. Tentatively applied ***to*** the present *case* of wool up-step d e mean effect over 60 minutes might be *in* the region of 20 to 30% *of* the human metabolic heat at rest.

Although the effect of the material **was** studied to a limited exent only and at some favourable level, the findings showed that heat changes **of** wool due to changes of RH *can* be of a magnitude easy to perceive. Moreover, there were **indications** that the **buffering quality** ***of*** a hygroscopic fibre is *not* just a question of heat changes but also of the capacity of the fibre to damp the instant impression **of a *change.*** However, further target oriented research is required to quantify the hygroscopic effect in a way that **would** make **it** most useful in everyday life.

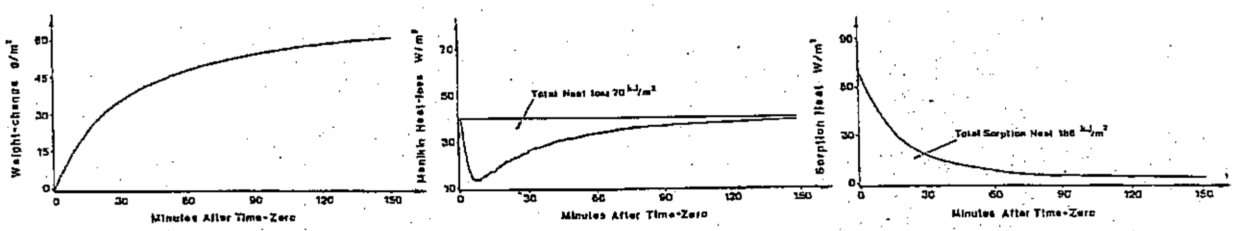

Figure 1. Response to absorption in **manikin** experiment **using** 1.0 **wool** ensemble.

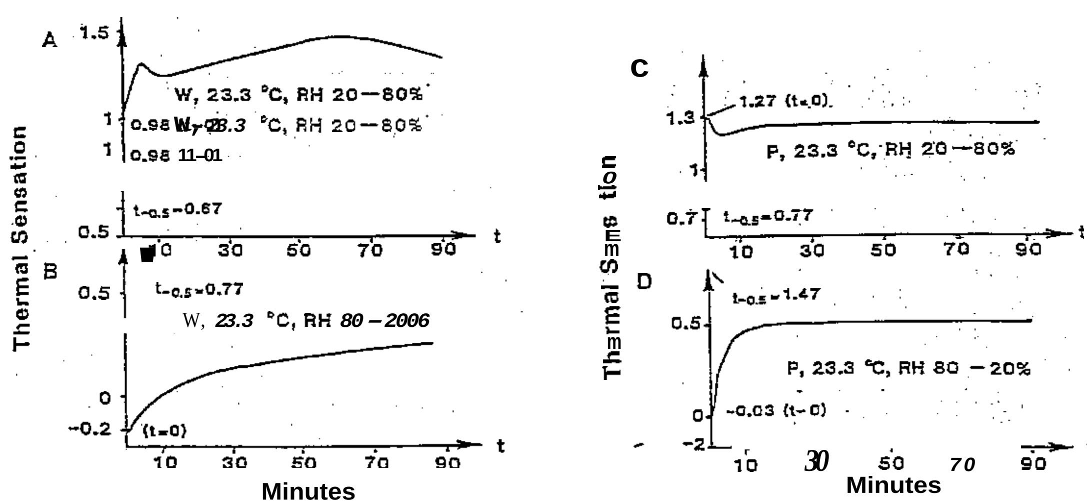

Figure 2. Mean themal sensations during humidity step-changes while wearing IO clo wool (W) or polyester (P) ensembles.

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