The effect of temperature gradient on the cooling rate of phase change material vests

Gao, Chuansi; Kuklane, Kalev; Holmér, Ingvar

Published in:
[Publication information missing]

2009

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
The effect of temperature gradient on the cooling rate of phase change material vests

Chuansi Gao, Kalev Kuklane, Ingvar Holmér
The Thermal Environment Laboratory, Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Faculty of Engineering (LTH), Lund University, Sweden

Contact person: Chuansi.Gao@design.lth.se

Phase change material (PCM) vests can be used to cool the microclimate around human body in the heat, e.g., firefighting. The temperature gradient ($T_{gr}$) between skin temperature and PCM melting temperature ($T_m$) might have been the factor accountable for insufficient cooling effects in some earlier studies. The objective of this study was to physically quantify the relationship between temperature gradient and PCM cooling rate.

Three cooling vests tested with PCMs (inorganic salts) at three melting temperatures 24, 28, and 32 °C, had the same design, surface area, and mass. Before and after the tests, the vests were kept at 20 °C overnight for solidifying and preparing for re-use. Clothing worn on the manikin was Swedish RB90 fire fighting ensembles. These include T-shirt, briefs, RB90 underwear and outerwear, socks, and gloves. The PCM cooling vest was worn between T-shirt and RB90 underwear. Thermal insulation without the vest was 2.78 clo (0.431 m$^2$ °C/W).

Thermal manikin Tore with 17 individually controlled zones with manikin surface temperature at 38 °C was used in order to assess the cooling rate in heat stress conditions. The vests were loaded with PCM packs (24, 28 and 32 °C), accordingly the resulting temperature gradients were at 6, 10, and 14 °C. Climatic chamber air temperature was kept the same as manikin surface temperature (isothermal condition), so that there was theoretically no heat loss from the manikin to the environment. As the cooling vest covered only torso part of the manikin, therefore chest, abdomen, upper and lower back zones were included in calculations for determining the cooling effects on the torso.

The results showed that among the torso heat losses of the thermal manikin at 38 °C in isothermal conditions, PCM24 has the highest cooling rate due to a greater temperature gradient (14 °C) even though the total latent heat is the smallest. The cooling rate/slope (-0.2949 W/m$^2$.min) was the steepest. On the contrary, the cooling rate was the smallest for PCM32 (slope: -0.0354 W/m$^2$.min). Obviously the duration of the cooling effect is shorter for PCM24, lasted about 2.5 hours due to the highest cooling rate. PCM32 has the smallest cooling rate and longest cooling duration (lasted more than six hours). The cooling rate of the PCM vests tested is positively correlated with the temperature gradient.