COMPARISON OF THERMAL HAND MODELS AND MEASUREMENT SYSTEMS

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Published in:
Proceedings of Ambience 14&10i3m

2014

COMPARISON OF THERMAL HAND MODELS AND MEASUREMENT SYSTEMS

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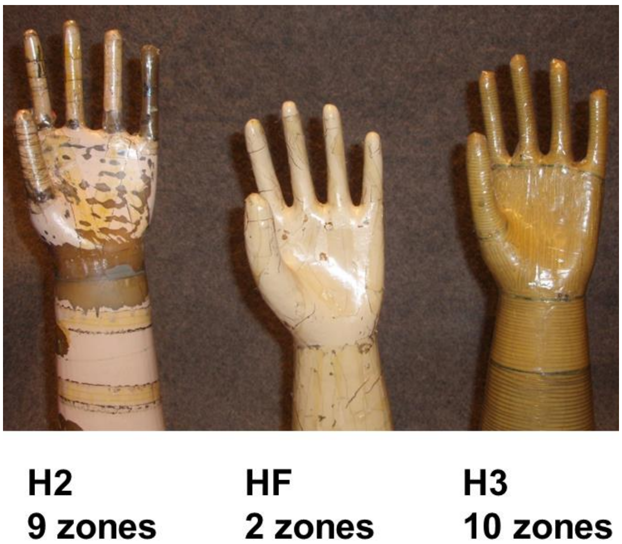
Abstract

Five sets of gloves were tested on 3 hand models with 2 measuring system in order to ensure repeatability of results from the past and for the future. The other aims of the study were to compare the possible differences related to different number of measuring zones, and effect of temperature distribution over hand surface. The hand models had 2 (HF), 9 (H2) and 10 (H3) zones respectively. Models H2 and H3 were tested on the new regulation system and models H2 and HF on the old regulation system. Homogenous vs. inhomogeneous surface temperature was tested on H2 and HF. All hands were tested at low (0.3 m/s) and high (4.0 m/s) air velocity. Non-uniform temperature did not affect the results if parallel method of EN ISO 15831 was applied. A higher insulation value was acquired with a one zone model vs. multiple zones. The transfer to new system did not affect the results.

Keywords: *thermal hand model, glove insulation, number of zones, surface temperature distribution, new and old regulation system*

1 Introduction

The old hand model [1] of the Thermal Environment Laboratory had become quite old and brittle, and a new model was therefore needed. Also, the regulation system needed an update as new computers do not fulfill requirements for earlier programs. Simultaneously, it has been continuously up a discussion if number of zones and temperature distribution may affect the measuring results. Some questions have been ansered by intensive studies on serial and parallel method comparisons [2-7], while some still need to be answered. Thus, preparing new hand models with different number of zones and using 2 different measuring systems, and testing in the same facilities would allow to cover the questions on the possible effects of zone number, measuring systems and possibly also on temperature distribution on the hand surface. Still, the major aim was to ensure that going over from an old hand model and an old regulation system to a new hand model and a new regulation system would produce repeatable results.



a)

b)

Figure 1 The used a) hands, and b) hand wear

2 Methods

Three hand models were used to test 5 sets of gloves (4 from Hestra and one firefigther glove from RB90 set, **Figure 1**) with 2 measuring systems. The hand models had 2 (HF), 9 (H2, old) and 10 (H3) zones respectively. Models H2 and H3 were tested on the new regulation system (National Instruments components and LabView based) and models H2 and HF on the old regulation system (DOS-based). Effects of homogenous (uniform) vs. Inhomogeneous (non-uniform) surface temperatures was tested on H2 and HF. For HF (1 measuring and 1 guard zone) it was expected that the hand surface kept inhomogenous temperature for different hand areas due to hand shape, areas' position and the same power to whole hand. Inhomogenous surface temperature condition of H2 was created by setting finger temperatures to 32 °C, and palm and back of hand temperatures to 36 °C. The real surface temperatures had even higher temperature differences. Homogenous temperature meant that all zones were set to 34 °C. All hand models were tested at low (0.3 m/s) and high (4.0 m/s, according to EN 511 [8]) air velocity in a wind tunnel. Calculations by EN 511 [8] were used when applicable (HF) or carried out by parallel method of EN 15831 [9] (H2, H3).

3 Results and discussions

Non-uniform temperature in itself did not affect the results if parallel method of EN ISO 15831 [9] was applied (**Figure 2**). There was an effect of one zone hand model vs. multiple zones – higher insulation value was acquired with a one zone model, especially, when glove insulation was high (**Figure 2**). It is not clear why did the difference occur, while according to H2 comparison with uniform (34 °C surface temperature) and non-uniform surface temperature the surface temperature distribution should not be an issue for total insulation.

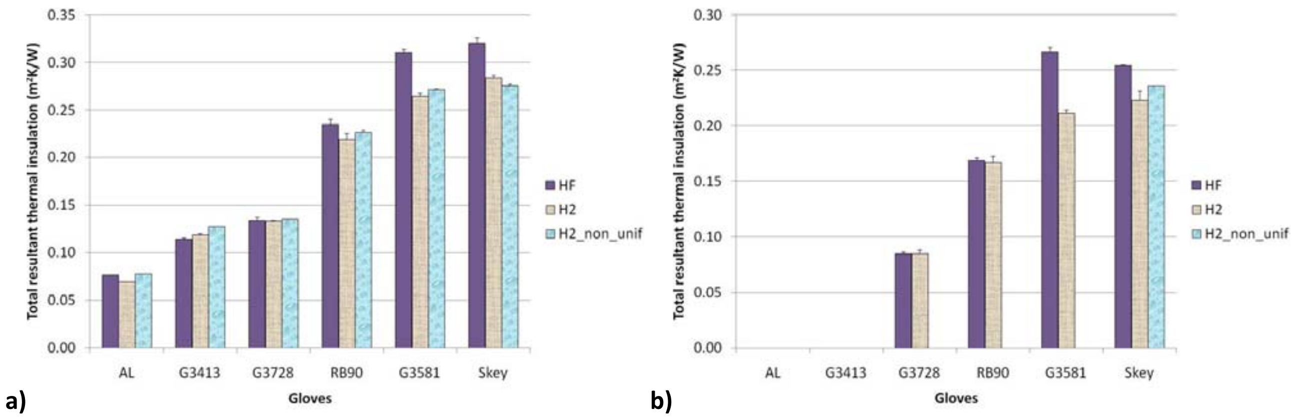


Figure 2 Uniform vs. non-uniform surface temperature at a) low air velocity; b) high air velocity. AL is air layer insulation around bare hand

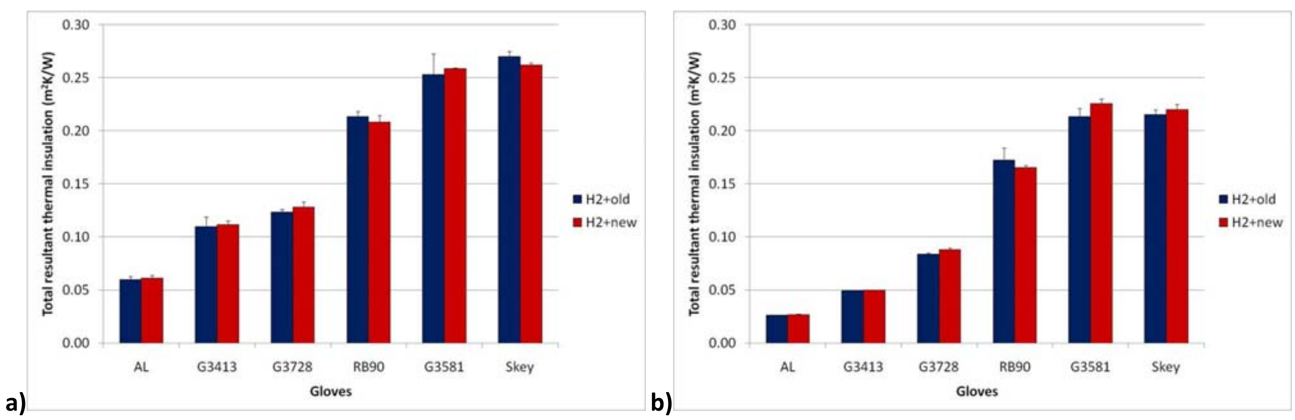


Figure 3 Old vs. new system at a) low air velocity; b) high air velocity. AL is air layer insulation around bare hand

The transfer to new system did not affect the results – the models allowed to be used with different systems with minimal effect on calculated thermal resistance (**Figure 3**). New model did produce similar insulation values as the old model on thinner gloves, but the insulation was somewhat higher on the warmest hand wear (**Figure 4**). Reasons are not well understood but these might be related to somewhat different shape and diameter of the fingers and hand. Maybe that additional tests with more mittens where finger size may have less influence on total insulation or tests on a cylindrical model with similar clothing outer and varying inner diameter can clarify this. However, the insulation results of HF and H3 that had very similar shapes still did differ to quite some extent (**Figures 2** and **4**) while behaviour for a mitten was similar. Dependence on air velocity could be related to air permeability and no flow between the fingers.

a)

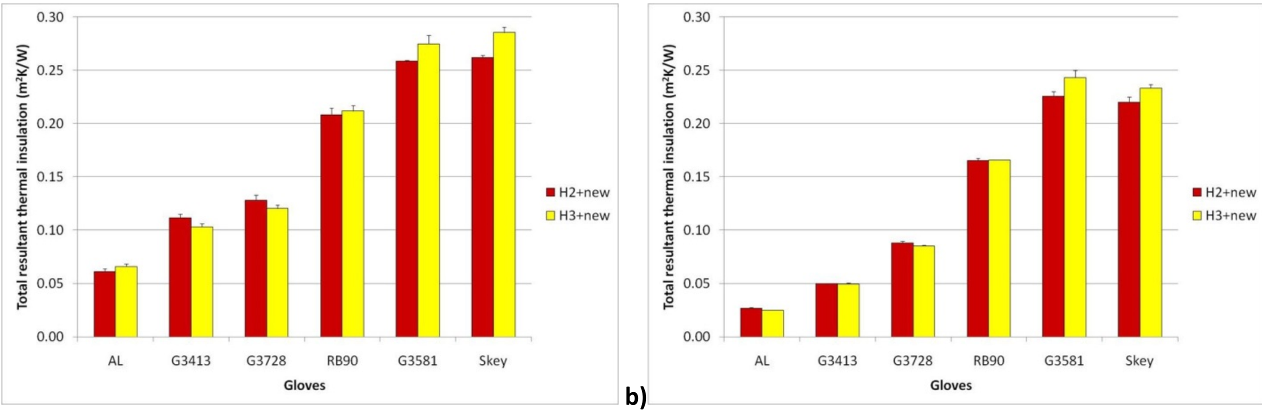


Figure 4 Old vs. new hand at a) low air velocity; b) high air velocity. AL is air layer insulation around bare hand

4 Conclusions

Non-uniform temperature in itself did not affect the results if parallel method of EN ISO 15831 was applied. There was an effect of one zone hand model vs. multiple zones – higher insulation value was acquired with a one zone model, especially, when glove insulation was high. The transfer to new system did not affect the results – the models allowed to be used with different systems, and measurements produce repeatable results. New model did produce similar insulation values as the old model on thinner gloves, but somewhat higher values on the warmest hand wear. As for hand model comparison the mean differences are insignificant while the change from thin to thick gloves is worth to be studied further

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