

THE USE OF THERMAL MANIKINS IN ENVIRONMENTAL ERGONOMICS

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Thermal manikins with computer-controlled heat supply to the skin surface, usually divided into 15-20 independently controlled sections, have now become a fairly standard tool in environmental ergonomics. As they can currently provide a rapid, accurate and reproducible simulation of the physical processes of dry heat **loss** to the environment, their main application is in the study of neutral or cold conditions at relatively low activity levels, i.e. in circumstances where it can be assumed that vapour diffusion resistance is adequately low and sweating can therefore occur efficiently, but is expected to provide a safety margin rather than to be a major, routine factor in heat balance. As the vast majority of artificially controlled work environments fall into this category, many non-sweating thermal manikins are already in use, although the first sectional manikin capable of controlled and continuous sweating is only now nearing completion.

Thermal manikins provide a good estimate of (a) the total dry heat loss from the body, a value that should be equal to the metabolic heat expected to be produced, less evaporative losses, and (b) the distribution of heat flow over the body surface, sectional heat flow values being a good guide to local thermal sensation, e.g. of draught, and to the risk of over-cooling active muscle groups and consequent cold-related injury. In a standard environment, these measures can be used to describe the thermal characteristics of clothing: total insulation value of an ensemble, local insulation values, the effects of drape, fit, pumping, self-convection, penetration by air movement or by wind, and compression of insulating fabric layers. With standard clothing, complex thermal environments such as those found in vehicles can be quantitatively compared and evaluated: the same measures can describe the effects of posture, seats, blocking and deflection of air currents by the body, self-convection, asymmetrical radiation, thermal gradients and direct sunshine. In both applications, the measures obtained from the manikin can be used as on-line feedback in a rapid empirical process of optimisation. Theoretical heat-balance equations are not yet able to predict the effects listed above, however accurately and completely the physical characteristics of the textiles, the thermal environment and the geometry of the workplace are known or can be measured. Thermal manikins in use today can bridge the gap between theory and practice. Though expensive, they can be surprisingly cost-effective.

Future developments include improved simulation of evaporative heat loss; improved software for simulating internal heat transfer, heat storage, and vasoconstriction: reactive programs with target total heat loss; empirical equations predicting manikin response in terms of temperature, air velocity, etc; and standard techniques for testing diving and survival suits.