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KEYNOTE ADDRESS

THE ACTUAL INSULATION OF MULTILAYER CLOTHING

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Clothing insulation is anything but a constant intrinsic clothing property. A number of factors modifies clothing insulation. Among these are insulation distribution over the body, temperature, exposed skin, and factors affecting the enclosed air between layers, such as posture, fit, mtion and Wind.
A simple physical model of clothed man was developed, showing that curvature of the clothing around the body does not play a large role in intrinsic insulation (without adjacent air layer), but that insulation distribution, and in particular exposed skin, makes the intrinsic insulation dependent on the environmental condition. This is in contrast to the aim of the concept of intrinsic insulation which is to obtain an independent clothing property. The model als shows that the **well** known rule of thumb that **local** clothing insulation equals to 4 clo per inch of thickness is a serious overestimation.
The insulation of clothing items is usually determined on thermal manikins, and the insulation of multilayer clothing ensembles is obtained from regression equations on the separate items. The literature agrees within close limits on the regression equations and also on the clothing outer surface area, but the use of the published tables of clothing item insulation introduces errors in practice. Determination of insulation by regression on weight, covered surface area and thickness **is** probably mre accurate.
The insulation thus obtained partains to standing subjects in quiet air. Any change in the enclosed air layers my modify the insulation. Analysis of the literature shows that the effects of posture, fit, mtion and wind are predictable with reasonable accuracy. Sitting changes the total insulation (clothing plus air) compared to standing. The effect varies from a slight increase for light clothing to a slight decrease for heavy clothing. Loose fit provides rmre insulation than tight fit: what is body tissue for an obese person becomes air for a lean person in the same clothing. Upper body mtion and lower body motion decrease total insulation with 20% each, almost regardless of the clothing. The **loss** of insulation due to wind depends on the clothing air permeability. The effect of wind, but also **of** Wind and motion together, *can* be reasonably well predicted. Even in moderate outdoor conditions such as walking in a light breeze, the actual insulation my already be less than half the manikin value.
The collected data enable extended application of thermoregulatory models, predicting comfort or themal strain in actual work situations.