

WIND-CHILL EQUATIONS PREDICTING WHOLE-BODY HEAT LOSS FOR A  
RANGE OF TYPICAL CIVILIAN OUTDOOR CLOTHING ENSEMBLES

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Using a 16-section thermal manikin with constant skin temperature (area-weighted mean value  $32.8^{\circ}\text{C}$ ) and a specially constructed wind-chill tunnel capable of maintaining constant air temperatures from  $-20^{\circ}$  to  $+20^{\circ}\text{C}$  and constant wind speeds up to  $4\text{ m/s}$ , whole-body heat loss was measured for 7 different outdoor clothing ensembles. These ranged from shirtsleeves ( $0.5\text{ clo}$ ) to a down-jacket ensemble ( $1.9\text{ clo}$ ) and were chosen to be representative of the full range of civilian outdoor clothing in common use for everyday, non-sporting wear. Equations fitting the data with correlation coefficients in excess of  $0.99$  were derived for each ensemble. Diagrams produced by using these equations to interpolate and extend the range of conditions are given. Conditions studied were those resulting in total heat loss values from  $50$  to  $250\text{ W/m}^2$ , so very little extrapolation was required. A diagram of wind-chill equivalent temperature (with reference to  $2\text{ m/s}$ ) is given, based on an average of all 7 ensembles, which showed good agreement on this measure, particularly at low temperatures. The values predicted on the basis of whole-body heat loss through clothing are shown to be much lower than those predicted from the Siple Wind-Chill Index for unprotected skin. The Siple Index does not take account of the penetration of clothing insulation by wind, and therefore under-estimates the cooling effect of wind at low temperatures for typical civilian outdoor clothing.