temperature pattern. The second type allows temperature control of specific zones. Such manikins allow the measurement of insulation but not vapor permeability of clothing ensembles. These manikins have fifteen individually heated zones which allow control of the surface temperature pattern. The third type of manikin is a sectional manikin which measures overall and individual regions for insulation and vapor permeability properties. This manikin has six thermally isolated, individually controlled sections which allow control over surface temperature pattern.

All of the static manikins are presently manually controlled with AC power. Work is underway to modify these manikins with individual DC power supplies thereby allowing use of computer control and data acquisition system.

5) Copper manikin (articulated) - This manikin has nineteen individually heated zones that control surface temperature pattern and measure insulation and vapor permeability of clothing ensembles. This manikin has the potential of generating walking motion up to 1.56 $m.s^{-1}$ thereby allowing the study of thermal changes in clothing associated with movement.

50 **Heat loss from boots under simulated field conditions**

W.R. Santee and T.L. Endrusick, US Army Research Institute for Environmental Medicine, Natick, Massachusetts, USA

During cold weather, reduction of footwear insulation due to exposure to moisture in the form of liquid or snow is a significant problem. The current test procedure is to fit a dry boot over a sectionally heated, copper foot and apply 70kg of pressure to simulate the compression effects of body mass on insulation. The results of the standard test are based only on data for dry boots and are presented as a single value for total dry insulation (I_T) derived from a weighted summation of the heat loss from each foot segment. The standard method ignores the possible reduction in effective insulation due to wetting of the boot and regional differences in heat exchange. The present study describes the regional and overall effects of exposure to moisture on heat loss from footwear and discusses the advantages of this additional information in evaluating cold weather footwear.

Eight boots including leather, leather/synthetic, shoepac and all rubber designs, were fitted over a regionally heated, copper foot model and placed in an environmental chamber controlled at 2°C. The test:

a) I_T was determined for the dry boot
b) Footwear placed in 5 cm water for 7 hours, heat loss measured
c) Footwear removed from water, heat loss determined for 20+ hrs

After soaking for 7 hours, the reduction in I_T values ranged from 1 to 23% for eight boot types. For the combined heel and toe regions, the decrease in local insulation values for the eight boots ranged from 5 to 30%. The recovery in I_T for wet boots 22.5 hours after removal from water ranged from 6 to 9% for three leather or leather/synthetic boots.

Current "standard" test procedures produce misleading estimates of heat loss from footgear under cold, wet conditions. The performance of footwear under wet conditions cannot be predicted solely on the basis of the performance of dry boots because the reduction in insulation due to exposure to moisture is dependent, in part, on the design, materials and construction of the individual boot. By determining heat transfer from footgear mounted on a copper foot model, the degree to which standard test procedures underestimate heat loss under field conditions can be evaluated. On the basis of such evaluations a recommendation regarding a possible modification or addition to standard test procedures for evaluating footgear shall be presented.