Proceedings of 3rd International Conference on Environmental Ergonomics
8—12 August 1988 Helsinki, Finland
eds. R. Ilmarinen and A. Påsche, p. 65

MOISTURE PERMEABILITY OF CLOTHING SYSTEMS

Elizabeth A. McCullough and Byron W. Jones

Institute for Environmental Research

Address for reprints:

Kansas State University
Seaton Hall
Manhattan, Kansas 66506 U.S.A.

The ability of a clothing ensemble to allow the evaporation of sweat from the skin is an important factor in determining its suitability for a given thermal environment. This factor is particularly important when a person has a high activity level and/or is subjected to heat stress. ISO and ASHRAE/ANSI standards have adequate data bases and estimation techniques for determining thermal insulation, but have very little or no information for determination of moisture permeability. The purpose of this study was to collect moisture permeability data on a wide range of clothing ensembles and fabrics and to develop a technique for estimating ensemble moisture permeability from information about the ensemble and its component fabrics. Thermal insulation and moisture permeability were measured for 20 clothing ensembles using a sweating thermal manikin. Insulation and moisture permeability values for the component fabrics and other materials were measured on a sweating hot plate. Data were also collected for each clothing ensemble describing the coverage of each part of the body and the thickness of the air layers created by the clothing.

It is difficult to develop a clothing data base that will include every ensemble of interest. Therefore, an important part of the study was to develop a technique that can accurately estimate the moisture permeability of clothing ensembles. It was shown in earlier work that the thermal insulation of an ensemble can be predicted from simple heat transfer relationships if the ensemble is divided into segments such that each segment is uniformly clothed ("A Comprehensive Data Base for Estimating Clothing Insulation," ASHRAE Transactions, Vol. 91, Pt. 2, 1985). This modeling approach was extended to moisture permeability in the present study. The body is divided into 12 main segments, each of which can be divided into as many subsegments as needed. The moisture transfer resistances of the air layers and fabric layers are added to get the total resistance and to determine the evaporation potential for each segment. These are summed for all segments to determine the moisture evaporation potential for the entire body. From this information, the permeability index or other measures of moisture permeability for the clothing ensemble can be calculated, or local moisture permeability can also be estimated.

By using a model based on a theoretically correct description of heat and moisture transfer, the moisture permeability of clothing ensembles can be estimated from fabric level data with a minimum of empirical constants and relationships. The equations in the model are not complex, but when all of the subsegments are included, a lot of information about a given clothing ensemble is accounted for in the calculations. Use of the model is a bit tedious but straight forward. All that is needed to estimate the moisture permeability of a clothing ensemble is a tape measure, a "store" manikin (or a patient person) to "wear" the clothing, and thickness and moisture permeability data for the component fabrics. Thickness can be measured with a conventional compressometer and moisture permeability can be estimated from the fabric data base developed in this study or from sweating hot plate measurements. The 20 clothing ensembles evaluated in the laboratory represent a wide range of thermal insulations and moisture permeabilities and demonstrate that this approach will give accurate estimates of clothing moisture permeability.