PHYSICAL TECHNIQUES FOR DETERMINING THE RESISTANCE TO HEAT TRANSFER PROVIDED BY CLOTHING

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It is necessary to quantify the thermal insulation and evaporative resistance properties of clothing systems so that the heat exchange between the body and the environment can be determined and a person's performance in that environment can be predicted using biophysical models. This paper reviews the physical methods for directly measuring resistance data on fabrics and clothing ensembles and discusses problems associated with different techniques. In addition, methods for estimating the resistance values for clothing from different fabric and clothing properties will be mentioned.

FABRICS

The resistance to dry heat transfer (i.e., insulation) can be measured using the rate of cooling method, the constant temperature method (e.g., guarded hot plate), and heat flow meter. Flat plate instruments or cylinders have been used, with each type having advantages and disadvantages over the other. Fabric insulation can be estimated from thickness, so the compressometer, micrometer, and pendulum methods will be discussed. The evaporative resistance of fabrics can be measured using a sweating hot plate device or cylinder. A liquid barrier of known resistance is needed to keep the fabric dry during the test. Measurements can be made with and without a temperature gradient between the hot body and the environment. Other methods for measuring the diffusion of water vapor through a fabric include the ASTM control dish method and the Canadian DND apparatus. [1-10]

CLOTFDNG TESTS

Thermal manikins are constant temperature methods for measuring the insulation values of clothing ensembles. They take into account several variables that affect heat transfer from the body (i.e., the amount of body surface area covered by clothing, the distribution of the insulation over the body, the looseness or tightness of fit, and the increased surface ares for heat loss. Manikins can be divided into body segments with independent temperature control and measurement or consist of one circuit. They can be made to sweat externally by using a cotton knit skin saturated with water, but this test is a transient one. Efforts to develop manikins with steady-state sweating capability are still underway. Manikins also can be attached to auxiliary motion systems so that clothing ventilation can be studied. [11-20]

DYNAMIC VS. STEADY-STATE TESTS

These test methods have been criticized because they are conducted under steady-state conditions whereas, a person wearing clothing is moving around--changing body position, movements, and environments. Thus, quantifying the thermal responses of clothing to transient conditions is important. A thermal manikin can be used to quantify the changes in insulation due to temperature and humidity transients by moving the manikin from one environment to another, or by changing the environment around him. A manikin can be used to quantify the effect of body position and motion on the insulation value of the clothing also. Unfortunately, these tests have not been conducted with the manikin sweating, so changes in evaporative heat transfer must be estimated from fabric and clothing data. [21]

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