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Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)

Textiles — Effets physiologiques — Mesurage de la résistance thermique et de la résistance à la vapeur d'eau en régime stationnaire (essai de la plaque chaude gardée transpirante)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 38, *Textiles.*

This second edition cancels and replaces the first edition (ISO 11092:1993), which has been technically revised. It also incorporates Amendment 1 to ISO 11092:1993 (ISO 11092:1993/Amd.1:2012).

Introduction

This International Standard is the first of a number of standard test methods in the field of clothing comfort.

The physical properties of textile materials which contribute to physiological comfort involve a complex combination of heat and mass transfer. Each may occur separately or simultaneously. They are time-dependent, and may be considered in steady-state or transient conditions.

Thermal resistance is the net result of the combination of radiant, conductive and convective heat transfer, and its value depends on the contribution of each to the total heat transfer. Although it is an intrinsic property of the textile material, its measured value may change through the conditions of test due to the interaction of parameters such as radiant heat transfer with the surroundings.

Several methods exist which may be used to measure heat and moisture properties of textiles, each of which is specific to one or the other and relies on certain assumptions for its interpretation.

The sweating guarded-hotplate (often referred to as the “skin model”) described in this International Standard is intended to simulate the heat and mass transfer processes which occur next to human skin. Measurements involving one or both processes may be carried out either separately or simultaneously using a variety of environmental conditions, involving combinations of temperature, relative humidity, air speed, and in the liquid or gaseous phase. Hence transport properties measured with this apparatus can be made to simulate different wear and environmental situations in both transient and steady-states. In this International Standard only steady-state conditions are selected.

Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)

1 Scope

This International Standard specifies methods for the measurement of the thermal resistance and water-vapour resistance, under steady-state conditions, of e.g. fabrics, films, coatings, foams and leather, including multilayer assemblies, for use in clothing, quilts, sleeping bags, upholstery and similar textile or textile-like products.

The application of this measurement technique is restricted to a maximum thermal resistance and water-vapour resistance which depend on the dimensions and construction of the apparatus used (e.g. 2 $m^2 \cdot K/W$ and 700 $m^2 \cdot Pa/W$ respectively, for the minimum specifications of the equipment referred to in this International Standard).

The test conditions used in this International Standard are not intended to represent specific comfort situations, and performance specifications in relation to physiological comfort are not stated.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
thermal resistance
R_{ct}
temperature difference between the two faces of a material divided by the resultant heat flux per unit area in the direction of the gradient

Note 1 to entry: It is a quantity specific to textile materials or composites which determines the dry heat flux across a given area in response to a steady applied temperature gradient. The dry heat flux may consist of one or more conductive, convective and radiant components.

Note 2 to entry: Thermal resistance is expressed in square metres kelvin per watt.

2.2
water-vapour resistance
R_{et}
water-vapour pressure difference between the two faces of a material divided by the resultant evaporative heat flux per unit area in the direction of the gradient

Note 1 to entry: It is a quantity specific to textile materials or composites which determines the “latent” evaporative heat flux across a given area in response to a steady applied water-vapour pressure gradient. The evaporative heat flux may consist of both diffusive and convective components.

Note 2 to entry: Water-vapour resistance is expressed in square metres pascal per watt.

2.3
water-vapour permeability index
i_{mt}
ratio of thermal and water-vapour resistances in accordance with Formula (1):

$$i_{mt} = S \cdot \frac{R_{ct}}{R_{et}} \qquad (1)$$

where S equals 60 Pa/K

Note 1 to entry: The water-vapour permeability index is dimensionless, and has values between 0 and 1. A value of 0 implies that the material is water-vapour impermeable, that is, it has infinite water-vapour resistance, and a material with a value of 1 has both the thermal resistance and water-vapour resistance of an air layer of the same thickness.

2.4
water-vapour permeability
W_d
characteristic of a textile material or composite depending on water-vapour resistance and temperature in accordance with Formula (2):

$$W_d = \frac{1}{R_{et} \cdot \phi T_m} \quad (2)$$

where ϕT_m is the latent heat of vaporization of water at the temperature T_m of the measuring unit, equals, for example, 0,672 W·h/g at T_m = 35 °C

Note 1 to entry: Water-vapour permeability is expressed in grams per square metre hour pascal.

3 Symbols and units

R_{ct}	is the thermal resistance, in square metres kelvin per watt
R_{et}	is the water-vapour resistance, in square metres pascal per watt
i_{mt}	is the water-vapour permeability index, dimensionless
R_{ct0}	is the apparatus constant, in square metres kelvin per watt, for the measurement of thermal resistance R_{ct}
R_{et0}	is the apparatus constant, in square metres pascal per watt, for the measurement of water vapour resistance R_{et}
W_d	is the water-vapour permeability, in grams per square meter hour pascal
ϕT_m	is the latent heat of vaporization of water at the temperature T_m, in watt hours per gram
A	is the area of the measuring unit, in square metres
T_a	is the air temperature in the test enclosure, in degrees Celsius
T_m	is the temperature of the measuring unit, in degrees Celsius
T_s	is the temperature of the thermal guard, in degrees Celsius
p_a	is the water-vapour partial pressure, in pascals, of the air in the test enclosure at temperature T_a
p_m	is the saturation water-vapour partial pressure, in pascals, at the surface of the measuring unit at temperature T_m
v_a	is the speed of air above the surface of the test specimen, in metres per second
S_v	is the standard deviation of air speed v, in metres per second
R.H.	is the relative humidity, in percent
H	is the heating power supplied to the measuring unit, in watts