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Foreword

This document (EN ISO 15831:2004) has been prepared by Technical Committee ISO/TC 38 "Textiles" in collaboration with Technical Committee CEN/TC 162 "Protective clothing including hand and arm protection and lifejackets", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2004, and conflicting national standards shall be withdrawn at the latest by August 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 15831:2004 has been approved by CEN as EN ISO 15831:2004 without any modifications.
Clothing — Physiological effects — Measurement of thermal insulation by means of a thermal manikin

1 Scope

This International Standard describes the requirements of the thermal manikin and the test procedure used to measure the thermal insulation of a clothing ensemble, as it becomes effective for the wearer in practical use in a relatively calm environment, with the wearer either standing or moving.

NOTE This thermal insulation, among other parameters, can be used to determine the physiological effect of clothing on the wearer in specific climate/activity scenarios.

2 Terms and definitions

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

2.1 clothing ensemble

group of garments worn together on the body at the same time

2.2 thermal insulation of clothing

temperature difference between the wearer's skin surface and ambient atmosphere divided by the resulting dry heat flow per unit area in the direction of the temperature gradient where the dry heat flow consists of conductive, convective and radiant components

NOTE Depending on the end use of the clothing, different thermal insulation values can apply.

2.2.1 total thermal insulation of clothing

\( I_t \)

total thermal insulation from skin to ambient atmosphere, including clothing and boundary air layer, under defined conditions measured with a stationary manikin

2.2.2 resultant total thermal insulation of clothing

\( I_{tr} \)

total thermal insulation from skin to ambient atmosphere, including clothing and boundary air layer, under defined conditions measured with a manikin moving its legs and arms
3 Symbols and units

- $a_i$: surface area of the body segment $i$ of the manikin, m$^2$
- $A$: total body surface area of the manikin, m$^2$
- $f_i$: fraction of the total manikin surface area represented by the surface area of segment $i$
- $H_c$: total heating power supplied to the manikin, W
- $H_{ci}$: heating power supplied to the body segment $i$ of the manikin, W
- $I_t$: total thermal insulation of the clothing ensemble with the manikin stationary, m$^2$K/W
- $I_{tr}$: resultant total thermal insulation of the clothing ensemble with the manikin moving, m$^2$K/W
- RH: relative humidity of the air within the climatic chamber, %
- $T_a$: air temperature within the climatic chamber, °C
- $T_s$: mean skin surface temperature of the manikin, °C
- $T_{si}$: skin surface temperature of the body segment $i$ of the manikin, °C
- $v_a$: air speed in the climatic chamber, m/s

4 Principle

The components of the clothing ensemble to be tested are placed on the manikin in the same arrangement as in practical use.

The manikin, in the shape and size of an adult human body and, for the measurement of $I_{tr}$, with movable legs and arms, is internally heated to a constant skin surface temperature, uniform over its body. The manikin is placed in a climatic chamber where defined air temperature and air speed can be set, and air humidity controlled.

There will be a dry heat flow from the manikin's skin surface area through the clothing into the ambient air, which is measured after steady-state conditions have been reached. From this heat flow, related to the nude manikin's body surface area, the clothing ensemble's thermal insulation can be calculated, considering the temperature difference between the manikin's skin surface and the ambient air.

The measurement is performed with the manikin stationary and/or moving its legs and arms, with a defined number of movements per minute and a defined stride length.

The insulation values obtained include the thermal insulation provided by the clothing and the adhering air layer around the body. They apply only to the particular clothing ensemble, as tested, and to the specific conditions of the test, particularly with respect to the air movement around the manikin.
5 Apparatus

5.1 Manikin

5.1.1 Size and shape

The manikin, made from metal or plastic, shall be constructed to simulate the body of an adult human, i.e. it shall consist of an anatomically formed head, chest, abdomen, back, buttocks, arms, hands (preferably with fingers extended to allow gloves to be worn), legs and feet. The manikin shall consist of at least 15 body segments, each independently controlled with regard to surface temperature and monitored for heat flow. These 15 body segments shall be arranged as shown in Figure 1. If the manikin consists of more than 20 body segments, in the evaluation of the measured data, adjacent segments shall be combined using Equation (3), in order to approximate the segment arrangement shown in Figure 1.

The body height of the manikin shall be \((1,70 \pm 0,15)\) m, with a body surface area of \((1,7 \pm 0,3)\) m\(^2\).

The manikin’s body proportions should correspond to those required for standard sizes of garments, because deviations in fit will affect the results.

For the measurement of \(I_t\) the manikin’s arms and legs shall be movable, with joints at the shoulder, hip and knee. For the measurement of the clothing ensemble’s resultant total thermal insulation, \(I_{tr}\), the manikin, mechanically driven, shall perform \((45 \pm 2)\) double steps per min, and \((45 \pm 2)\) double arm movements per min cross walking. The stride length, measured from toe to toe, shall be \((63 \pm 10)\) cm, and the length of the arm movements, measured between the wrists at the base of the thumbs, \((53 \pm 10)\) cm.

![Figure 1 — Schematic arrangement of the manikin’s body segments](image-url)