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Date: 01 May 2025

Origin: European

Latest date for receipt of comments: 24 June 2025

Project No. 2023/01283

Responsible committee: PH/9/-/1 Ergonomics of the physical environment

Interested committees:

Title: BS EN ISO 14505-2 Draft Ergonomics of the thermal environment — Evaluation of thermal environments in vehicles. Part 2: Determination of equivalent temperature.

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 14505-2

Ergonomics of the thermal environment — Evaluation of thermal environments in vehicles —

Part 2: Determination of equivalent temperature

*Ergonomie des ambiances thermiques — Évaluation des
ambiances thermiques dans les véhicules —*

Partie 2: Détermination de la température équivalente

ICS: 13.180; 43.020

ISO/TC 159/SC 5

Secretariat: **BSI**

Voting begins on:
2025-05-01

Voting terminates on:
2025-07-24

This document is circulated as received from the committee secretariat.

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Reference number
ISO/DIS 14505-2:2025(en)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 159, ergonomics, Subcommittee SC 5, ergonomics of the physical environment.

This second edition cancels and replaces the first edition (ISO 14505-2:2006), which has been technically revised.

The main changes are as follows:

- evaluation method for the contact areas (equivalent contact temperature)

A list of all parts in the ISO 14505 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The interaction of convective, radiative and conductive heat exchange in a vehicle compartment is very complex. External thermal loads in combination with the internal heating and ventilation system of the vehicle create a local climate that can vary considerably in space and time. Asymmetric thermal conditions arise, and these are often the main cause of complaints of thermal discomfort. In vehicles without or having a poor heating, ventilating and air-conditioning system (HVAC-system), thermal stress is determined largely by the impact of the ambient climatic conditions on the vehicle compartment. Subjective evaluation is integrative, as the individual combines into one reaction the combined effect of several thermal stimuli. However, it is not sufficiently detailed or accurate for repeated use. Technical measurements provide detailed and accurate information but require integration in order to predict the thermal effects on humans. Since several climatic factors play a role for the final heat exchange of a person, an integrated measure of these factors, representing their relative importance, is required. This standard includes the equivalent temperature models t_{eq} for the assessment of the thermal conditions. For special consideration of the seat, the equivalent contact temperature $t_{eq,cont}$ can be applied for body compartments in contact to surfaces.

Ergonomics of the thermal environment — Evaluation of thermal environments in vehicles —

Part 2: Determination of equivalent temperature

1 Scope

This part of ISO 14505 provides guidelines for the assessment of the thermal conditions inside a vehicle compartment. It can also be applied to other confined spaces with asymmetric climatic conditions. It is primarily intended for assessment of thermal conditions, when deviations from thermal neutrality are relatively small. Appropriate methodology as given in this part of ISO 14505 can be chosen for inclusion in specific performance standards for testing of HVAC-systems for vehicles and similar confined spaces.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13731, *Ergonomics of the thermal environment — Vocabulary and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13731 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

equivalent temperature t_{eq}

temperature of a homogenous space, with mean radiant temperature equal to air temperature and zero air velocity, in which a person exchanges the same heat loss by convection and radiation as in the actual conditions under assessment

3.2

whole body equivalent temperature $t_{eq,whole}$

temperature of an imaginary enclosure with the same temperature in air and on surrounding surfaces and with air velocity equal to zero in which a full-scale, human shaped, heated sensor will exchange the same dry heat by radiation and convection as in the actual non-uniform environment

3.3

segmental equivalent temperature $t_{eq,segment}$

uniform temperature of an imaginary enclosure with the same temperature in air and on surrounding surfaces and with air velocity equal to zero in which one or more selected zones of a thermal manikin will exchange the same dry heat by radiation and convection as in the actual non-uniform environment

3.4**directional equivalent temperature** $t_{eq,direct}$

uniform temperature of an imaginary enclosure with the same temperature in air and on surrounding surfaces and with air velocity equal to zero in which a small flat heated surface will exchange the same dry heat by radiation and convection as in the actual non-uniform environment

3.5**omnidirectional equivalent temperature** $t_{eq,omni}$

uniform temperature of an imaginary enclosure with the same temperature in air and on surrounding surfaces and with air velocity equal to zero in which a heated ellipsoid will exchange the same dry heat by radiation and convection as in the actual non-uniform environment

3.6**equivalent contact temperature** $t_{eq,cont}$

uniform temperature of an imaginary contact surface, at room air speed close to zero, at which a person will exchange the same amount of dry heat through thermal conduction for a virtual clothing insulation as in the actual non-uniform environment, where the person experiences sensible and latent heat transfer at the considered body parts

3.7**segment**

part of a human-shaped sensor, normally corresponding to a real body-part, consisting of one or several whole zones, for which a segmental equivalent temperature, $t_{eq,segment}$, is presented

3.8**zone**

physical partition of a manikin, which is independently regulated and within which the surface temperature and heat exchange is measured

3.9**HVAC-system**

heating, ventilating and air-conditioning system of the vehicle and/or cabin

4 Assessment principles

The assessment principle is based on the measurement of the equivalent temperature. The equivalent temperature provides a unified, physical measure of the climatic effects on the human dry heat exchange. On the basis of the actual value for, and the variation in, equivalent temperature, it is possible to predict the conditions for heat balance under conditions in or close to the thermoneutral zone. People's thermal sensation is primarily influenced by general and local levels and variations in skin surface heat flux. Values for the equivalent temperature of a defined environment have been found to be closely related to how people perceive thermal conditions when exposed to the same environment. This can be used for the interpretation of the t_{eq} value and assessment of the quality of the environment.

The climate is assessed in terms of a *total equivalent temperature*, which describes the level of *thermal neutrality*.

The climate is also assessed for local effects on defined parts of the human body surface. The *local equivalent temperatures* determine to what extent the actual body parts fall within the range of acceptable levels of heat loss (*local discomfort*).

4.1 General description of equivalent temperature

The equivalent temperature is a pure physical quantity, that in a physically sound way integrates the independent effects of convection and radiation on human body heat exchange. This relationship is best described for the overall (whole body) heat exchange. There is limited experience with relations between local dry heat exchange and local equivalent temperature. The standardized definition of t_{eq} applies only for the whole body. Therefore, the definition has to be modified for the purposes of this part of ISO 14505. t_{eq}

does not take into account human perception and sensation or other subjective aspects. However, empirical studies show that t_{eq} values are well related to the subjective perception of the thermal effect.

4.2 General determination principle of equivalent temperature

Determination of t_{eq} is based on equations for convective and radiative heat transfer for clothed persons. Heat exchange by conduction is assumed to be small and accounted for by radiation and convection.

$$R = h_r \times (t_{sk} - \bar{t}_r) \quad (1)$$

$$C = h_c \times (t_{sk} - t_a) \quad (2)$$

where

R is heat exchange by radiation, in watts per square metre (W/m^2);

C is heat exchange by convection, in watts per square metre (W/m^2);

h_r is the radiation heat transfer coefficient, in watts per square metre degree Celsius [$\text{W}/(\text{m}^2 \text{ } ^\circ\text{C})$];

h_c is the convection heat transfer coefficient, in watts per square metre degree Celsius [$\text{W}/(\text{m}^2 \text{ } ^\circ\text{C})$];

t_{sk} is the skin temperature, in degrees Celsius ($^\circ\text{C}$);

$\bar{t}_r$ is the mean radiant temperature, in degrees Celsius ($^\circ\text{C}$);

t_a is the ambient air temperature, in degrees Celsius ($^\circ\text{C}$).

In practice the equivalent temperature is determined and defined by

$$t_{eq} = t_s - \frac{Q}{h_{cal}} \quad (3)$$

where

t_s is the surface temperature, in degrees Celsius ($^\circ\text{C}$);

t_{eq} is the temperature of the standard environment, in degrees Celsius ($^\circ\text{C}$);

Q is the measured convective and radiative heat loss during the actual conditions, in watts per square metre (W/m^2);

$$Q = R + C \quad (4)$$

h_{cal} is the combined heat transfer coefficient, determined during calibration in a standard environment, in watts per square metre degree Celsius [$\text{W}/(\text{m}^2 \text{ } ^\circ\text{C})$].

The standard environment comprises homogenous, uniform thermal conditions with $t_a = \bar{t}_r$ and air velocity $v_a < 0,1 \text{ m/s}$. A suitable calibration procedure is described in [Annex C](#).

5 Specific equivalent temperatures

5.1 General

As there is no method available for measurement of the true total or local t_{eq} , four specific equivalent temperatures are calculated according to different principles, according to 5.2 to 5.5. Depending on different measuring principles, they are defined as

1. whole body equivalent temperature,
2. segmental equivalent temperature,
3. directional equivalent temperature,
4. omnidirectional equivalent temperature.

5.2 Whole body equivalent temperature

5.2.1 Determination principle

The principle of determination is to measure the total heat flow from a human-sized test manikin consisting of several zones, each with a specific measured surface temperature similar to that of a human being. Theoretically whole body equivalent temperature can be measured with thermal manikins or a large number of flat heated sensors attached to an unheated manikin. The accuracy of the result is depending on surface temperature, size of body, number and division of zones, posture etc. An appropriate method to use is a thermal manikin divided into separate, individually heated zones covering the whole body, with surface temperatures close to that of a real human being. A human-sized manikin with only one zone will not determine a realistic whole body t_{eq} because the thermal conditions vary too much over the surface. The more zones the manikin has, the more correct value it will measure.

5.2.2 Calculation

$$t_{eq,whole} = t_{sk,whole} - \frac{Q_{whole}}{h_{cal,whole}} \quad (5)$$

$$t_{sk,whole} = \frac{\sum (t_{sk,n} \cdot A_n)}{\sum A_n} \quad (6)$$

$$Q_{whole} = \frac{\sum (Q_n \cdot A_n)}{\sum A_n} \quad (7)$$

where

A is a weighting factor based on the surface area;

$h_{cal,whole}$ is determined by calibration in a standard environment (see [Annex C](#));

n is the number of zones of the body ($0 < n \leq N$).

In order to be able to compare results from other manikins, the measured t_{eq} should be presented together with specifications of the manikin used, such as regulation principle, skin temperature, number of zones etc. (see [Annexes A](#) and [B](#)).