Technical Report

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Ergonomics of the thermal environment: Adaptive methods for achieving thermal comfort

Ergonomie des ambiances thermiques : Méthodes adaptives pour atteindre le comfort thermique

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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.

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

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.

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Introduction

This document is one of a series of standards, specifying methods of measuring and evaluating moderate and extreme thermal environments to which people are exposed at working practices.

In this series of standards, there already exist several documents related to moderate thermal environments at working practices.

— ISO 7726, *Ergonomics of the thermal environment — Instruments for measuring physical quantities*;

— ISO 7730, *Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*;

— ISO 8996, *Ergonomics of the thermal environment — Determination of a metabolic rate*;

— ISO 9920, *Ergonomics of the thermal environment — Estimation of thermal insulation and water vapour resistance of a clothing ensemble*;

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

— ISO/TS 13732-2, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 2: Human contact with surfaces at moderate temperature*;

— ISO 14505 (series), *Ergonomics of the thermal environment — Evaluation of thermal environments in vehicles*;

— ISO 17772-1, *Energy performance of buildings — Indoor environmental quality — Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings*;

— ISO 17772-2, *Energy performance of buildings — Overall energy performance assessment procedures — Part 2: Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings*.

These standards give methods for evaluation of the thermal environment. This document covers the evaluation of thermal sensation and comfort considering seasonal adaptive mechanisms to moderate thermal environments.

A human being's thermal sensation is mainly related to the thermal balance of their body as a whole. This balance is influenced by physical activity and clothing, as well as the environmental parameters: air temperature, mean radiant temperature, air velocity and air humidity. At the same time, thermal sensation and comfort are additionally affected among others by seasonal differences in the human being's state of thermal adaptation. The mechanisms leading to thermal adaptation are grouped into physiological, behavioural, and psychological. These effects are only partially considered in other methods for determining thermal sensation. Adaptive thermal comfort models consider all known adaptive mechanisms in the prediction of thermal sensation votes or comfort ranges. Therefore, in this document, first, an overview of existing approaches is presented. Second, three examples of adaptive thermal comfort models are featured in this document. For each example, the background and model formulation, steps towards model development and implementation and the application in national and international standards are described.

This document is intended to be used with reference to ISO 28803, when considering persons with special requirements, such as those with physical disabilities. Ethnic, national or geographical differences must also to be taken into account.

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Ergonomics of the thermal environment: Adaptive methods for achieving thermal comfort

1 Scope

This document defines adaptive thermal comfort and its mechanisms, and describes current approaches to predict adaptive thermal comfort.

This document applies to human thermal comfort in indoor built environments and seasonal adaptive processes. It is applicable to healthy humans exposed to indoor environments where thermal comfort is desirable, but where moderate deviations from thermal comfort occur, in the design of new environments or the assessment of existing ones.

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
thermoregulation
accommodation
acute response to a (thermal) stimuli supporting homeostatic regulation

3.2
adaptation
changes that reduce the (physiological or psychological) strain produced by stressful components of the total environment

Note 1 to entry: This change can occur within the lifetime of an organism (phenotypic) or be the result of genetic selection in a species or subspecies (genotypic).

[SOURCE: *Glossary of terms for thermal physiology*]

3.2.1
adaptation
<behavioural> behavioural changes like changing posture or activity, clothing level adjustments or adjustments to the indoor thermal environment (e.g. window opening or using a fan) that affect the human body's heat balance

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3.2.2
adaptation
<physiological> altered response of the thermoregulation system through adjustments in physiological parameters, such as the onset of sweating as a consequence of repeated warm or cold stimuli that reduces thermal stress on the human body

3.2.3
adaptation
<psychological> changes in perception of, and reaction to, sensory information from thermoreceptors due to habituation, changed expectations, or perceived control influenced by a person's longer history of experiences with indoor and outdoor climate

3.3
adaptive thermal comfort
all known adaptive mechanisms in the prediction of thermal sensation votes or comfort ranges

3.4
mean daily outdoor air temperature
$\overline{t_{mda}}$
arithmetic mean of outdoor air temperature for a 24-hour period used to calculate prevailing mean outdoor air temperature ($\overline{t_{pma}}$)

3.5
mean monthly outdoor air temperature
$t_{a(out)}$
arithmetic average of the mean daily minimum and mean daily maximum outdoor (dry-bulb) temperatures for the month in question when used as an input variable for the adaptive model

3.6
neutral operative temperature
$t_{o\,n}$
operative temperature at which the average person will be thermally neutral

3.7
prevailing mean outdoor air temperature
$\overline{t_{pma}}$
arithmetic average of the mean daily outdoor temperatures over some period of days, which are no fewer than seven and no more than 30 sequential days prior to the day in question in the adaptive model

3.8
running mean outdoor temperature
t_{rm}
exponentially weighted running mean of the daily mean outdoor air temperature in the adaptive model

3.9
predictive mean vote
PMV

standard index that predicts the mean value of the votes of a large group of persons on the 7 point thermal sensation scale based on the heat balance of the human body

3.10
predicted percentage of dissatisfied
PPD

standard index that establishes a quantitative index related to the percentage of thermally dissatisfied people who feel too cool or too warm

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