

Ergonomics of the thermal environment -
Determination of metabolic rate (ISO 8996:2021)

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN ISO 8996:2021 sisaldab Euroopa standardi EN ISO 8996:2021 ingliskeelset teksti.	This Estonian standard EVS-EN ISO 8996:2021 consists of the English text of the European standard EN ISO 8996:2021.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 22.12.2021.	Date of Availability of the European standard is 22.12.2021.
Standard on kättesaadav Eesti Standardimis- ja Akrediteerimiskeskusest.	The standard is available from the Estonian Centre for Standardisation and Accreditation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 13.180

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardimis- ja Akrediteerimiskeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardimis- ja Akrediteerimiskeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autoriõiguse kaitse kohta, võtke palun ühendust Eesti Standardimis- ja Akrediteerimiskeskusega: Koduleht www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation and Accreditation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation and Accreditation.

If you have any questions about standards copyright protection, please contact the Estonian Centre for Standardisation and Accreditation: Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

English Version

Ergonomics of the thermal environment - Determination of metabolic rate (ISO 8996:2021)

Ergonomie de l'environnement thermique -
Détermination du métabolisme énergétique (ISO
8996:2021)

Ergonomie der thermischen Umgebung - Bestimmung
des körpereigenen Energieumsatzes (ISO 8996:2021)

This European Standard was approved by CEN on 3 December 2021.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN ISO 8996:2021) has been prepared by Technical Committee ISO/TC 159 "Ergonomics" in collaboration with Technical Committee CEN/TC 122 "Ergonomics" 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 June 2022, and conflicting national standards shall be withdrawn at the latest by June 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 8996:2004.

Any feedback and questions on this document should be directed to the users' national standards body/national committee. A complete listing of these bodies can be found on the CEN website.

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

Endorsement notice

The text of ISO 8996:2021 has been approved by CEN as EN ISO 8996:2021 without any modification.

Contents

Page

Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 The units.....	1
5 The four levels of methods for estimating the metabolic rate.....	1
6 Level 1, Screening: classification of metabolic rate by categories.....	3
7 Level 2, Observation.....	3
7.1 Evaluation of metabolic rate for a given activity.....	3
7.2 Evaluation of the mean metabolic rate over a given period of time.....	4
7.3 Accuracy.....	4
8 Level 3, Analysis.....	4
8.1 Evaluation of metabolic rate using heart rate.....	4
8.1.1 Principle of the method.....	4
8.1.2 Determination of the (<i>HR-M</i>) relationship for purely dynamic muscular work.....	5
8.1.3 Evaluation of the metabolic rate as a function of <i>HR</i> in real situations.....	6
8.2 Evaluation of metabolic rate by accelerometry.....	7
9 Level 4, Expertise.....	8
9.1 Evaluation of metabolic rate by measurement of oxygen consumption rate.....	8
9.1.1 Partial and integral method.....	8
9.1.2 Evaluation of metabolic rate from oxygen consumption rate.....	10
9.1.3 Evaluation of oxygen uptake.....	11
9.1.4 Calculation of metabolic rate.....	13
9.2 Evaluation of metabolic rate by the doubly labelled water method for long term measurements.....	13
9.3 Evaluation of metabolic rate by direct calorimetry — Principle.....	14
Annex A (informative) Evaluation of the metabolic rate at level 1, Screening.....	15
Annex B (informative) Evaluation of the metabolic rate at level 2, Observation.....	17
Annex C (informative) Evaluation of the metabolic rate at level 3, Analysis.....	21
Annex D (informative) Evaluation of the metabolic rate at level 4, Expertise.....	23
Annex E (normative) Correction of the heart rate measurements for thermal effects.....	25
Bibliography.....	27

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 122, *Ergonomics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 8996:2004), which has been technically revised.

The main changes to the previous edition are as follows:

- The metabolic rate associated with a given task and estimated using the methods described in this document is expressed in watts.
- At level 1, Screening, the method classifying metabolic rate according to occupation has been removed, and revised procedures are provided for the evaluation of metabolic rate for given activities (level 2, Observation) and when using heart rate (level 3, Analysis).
- The accuracy of the methods for estimating the metabolic rate has been reevaluated in light of the recent literature and consequently the integral method is no longer recommended at level 4, Expertise.

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 metabolic rate, as a conversion of chemical into mechanical and thermal energy, measures the energetic cost of muscular load and gives a quantitative estimate of the activity. Metabolic rate is an important determinant of the comfort or the strain resulting from exposure to a thermal environment. In particular, in hot climates, the high levels of metabolic heat production associated with muscular work aggravate heat stress, as large amounts of heat need to be dissipated, mostly by sweat evaporation. On the contrary, in cold environments, high levels of metabolic heat production help to compensate for excessive heat losses through the skin and therefore reduce the cold strain.

The estimations, tables and other data included in this document concern the general working population. Corrections can be needed when dealing with special populations, including children, aged persons or people with physical disabilities. Personal characteristics, such as body mass, may be used if the body is moved due to walking or climbing ([Annex B](#)). Gender, age and body mass are considered in [Annex C](#) for the evaluation of the metabolic rate from heart rate.

Ergonomics of the thermal environment — Determination of metabolic rate

1 Scope

This document specifies different methods for the determination of metabolic rate in the context of ergonomics of the thermal working environment. It can also be used for other applications, e.g. the assessment of working practices, the energetic cost of specific jobs or sport activities and the total energy cost of an activity. The methods are classified in four levels of increasing accuracy: level 1, Screening, with a table giving examples of activities with low, moderate and high metabolic rates; level 2, Observation, where the metabolic rate is estimated by a time and motion study; level 3, Analysis, where the metabolic rate is estimated from heart rate recordings or accelerometers measurements; and level 4, Expertise, where more sophisticated techniques are described. The procedure to put into practice these methods is presented and the uncertainties are discussed.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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/>

4 The units

The metabolic rate associated with a given task and estimated using the methods described in this document shall be expressed in watts.

If the task does not involve displacements, the metabolic rate will not vary as a function of the size and the weight of the subject. If it involves displacements, then the weight of the person shall be taken into account (see [Annex B](#)).

As the heat associated to this metabolic rate and produced inside the body leaves it essentially through the skin, thermophysiology usually express the metabolic rate per unit of body surface area in $\text{W}\cdot\text{m}^{-2}$ and the estimations of thermal comfort and thermal constraints described in ISO 7243, ISO 7730, ISO 7933 and ISO 11079 are done using metabolic rates in $\text{W}\cdot\text{m}^{-2}$.

5 The four levels of methods for estimating the metabolic rate

The mechanical efficiency of muscular work – called the ‘useful work’ – is low. In most types of industrial work, it is so small (a few per cent) that it is assumed to be nil. This means that the energy spent while working is assumed to be completely transformed into heat. For the purposes of this document, the metabolic rate is assumed to be equal to the rate of heat production.

[Table 1](#) lists the different approaches presented in this document for determining the metabolic rate.