SLOVENSKI STANDARD

SIST EN 28996:2001

01-marec-2001

Ergonomija - Določitev metaboličnega proizvajanja toplote (ISO 8996:1990)

Ergonomics - Determination of metabolic heat production (ISO 8996:1990)

Ergonomie - Bestimmung der Wärmeerzeugung im menschlichen Körper (ISO 8996:1990)

Ergonomie - Détermination de la production de chaleur métabolique (ISO 8996:1990)

Ta slovenski standard je istoveten z: **EN 28996:1993**

ICS:

13.180	Ergonomija	Ergonomics

SIST EN 28996:2001 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 28996

October 1993

UDC 331.101.:577.121:331.483.46:612.014.43

Descriptors: Human factors engineering, thermal comfort, measurements, metabolism, tables (data), computation, classifications

English version

Ergonomics - Determination of metabolic heat production (ISO 8996:1990)

Ergonomie - Détermination de la production de chaleur métabolique (ISO 8996:1990)

Ergonomie - Bestimmung der Wärmeerzeugung im menschlichen Körper (ISO 8996:1990)

This European Standard was approved by CEN on 1993-10-25. 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 Central Secretariat or to any CEN member.

The European Standards exist 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart,36 B-1050 Brussels

Ref. No. EN 28996:1993 E

Foreword

This European Standard is the endorsement of ISO 8996:1990. Endorsement of ISO 8996 was recommended by Technical Committee CEN/TC 122 "Ergonomics" under whose competence this European Standard will henceforth fall.

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 April 1994, and conflicting national standards shall be withdrawn at the latest by April 1994.

The standard was approved and in accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Endorsement notice

The text of the International Standard ISO 8996:1990 was approved by CEN as a European Standard without any modification.

INTERNATIONAL STANDARD

ISO 8996

First edition
1990-12-15

Ergonomics — Determination of metabolic heat production

Ergonomie — Détermination de la production de chaleur métabolique

Reference number
ISO 8996 : 1990 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8996 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Sub-Committee SC 5, *Ergonomics of the physical environment*.

Annexes A to G form an integral part of this International Standard.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Introduction

This International Standard is one of a series intended for use in the study of thermal environments. It covers the evaluation of metabolic heat production by determining the metabolic rate needed to evaluate comfort and thermal stress using the methods given in this series of International Standards.

This page intentionally left blank

Ergonomics — Determination of metabolic heat production

1 Scope

The metabolic rate, as a conversion of chemical into mechanical and thermal energy, measures the energetic cost of muscular load and gives a numerical index of activity. A knowledge of metabolic rate is necessary to measure metabolic heat production for the evaluation of human heat regulation. Specifying methods for determination metabolic rate, this International Standard can also be used for other applications — for example: the assessment of working practices, the cost of specific jobs or sport activities, the total cost of activity, etc.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7933 : 1989, *Hot environments — Analytical determination and interpretation of thermal stress using calculation of required sweat rate.*

ISO 9886 : —[1], *Ergonomics — Evaluation of thermal strain by physiological measurements.*

3 Principle and accuracy

Since most of the energy produced by an organism is converted into thermal energy, the mechanical fraction — called the "useful work" (W) — can normally be neglected and the metabolic heat production can be equated with the metabolic rate (see ISO 7933).

Table 1 gives three approaches for determining metabolic rate.

Table 1 — Levels for the determination of the metabolic rate

Level	Method	Accuracy	Inspection of the work place
I	A — Classification according to kind of activity	Rough information where the risk of error is very great	Not necessary
	B — Classification according to occupation		Information on technical equipment, work organization
II	A — Use of tables of group assessment	High error risk Accuracy: ± 15 %	Time study necessary
	B — Use of estimation tables for specific activities		
	C — Use of heart rate under defined conditions		Not necessary
III	Measurement	Risk of errors within the limits of the accuracy of the measurement and of the time study Accuracy: ± 5 %	Time study necessary

1) To be published.

At level I, two methods are given for the estimation of metabolic rate. Method A is a classification according to the kind of activity, method B is a classification according to occupation. Both methods provide a rough estimate and there is considerable scope for error. This limits their accuracy considerably. At this level an inspection of the work place is not necessary.

At level II, using method A, the metabolic rate is determined by adding the basal metabolic rate to the metabolic rate for body posture, the metabolic rate for type of work and the metabolic rate for body motion related to work speed (tables of group assessment). Using method B the metabolic rate is determined by means of the tabulated values for various activities. The possibility that errors may arise is high. A time study is necessary to determine the metabolic rate of work which involves a cycle of different activities. Using method C the metabolic rate is determined by measuring heart rate. This method for indirect determination of metabolic rate is based on the relationship between oxygen uptake and heart rate under defined conditions.

At level III the metabolic rate is determined by direct measurement. A detailed time study is necessary during measurement.

The accuracy of each method is limited by several factors.

When looking at a single person performing a task at one time the main factors can be described as follows.

NOTE — The accuracy values given in table 1 take these factors into account.

In the case of the tables, differences between the observers and their level of training mainly influence the results. Using method C of level II, the accuracy of the relationship between oxygen uptake and heart rate because of existing other stress factors, which cannot be neglected, must be taken into account.

Cultural differences also influence the results. At level III, the measurement accuracy (determination of gas volume and oxygen fraction) will determine the degree of error.

In case of standardization of the results — for example a general statement relating to work places — other factors such as

- individual variability
- differences in work equipment
- differences in work speed
- differences in work technique

influence the possible accuracy of each method (see 4.6.2).

Thus the accuracy of the results and also the costs involved increase from level I to level III. Direct measurement gives the most accurate values. As far as possible the most accurate method should be used.

4 Tables for the estimation of metabolic rate

4.1 Classification of metabolic rate by kinds of activities

The metabolic rate can be estimated approximately using the classification given in annex A. Here the metabolic rate for a given activity is classified into one of five classes (resting, low metabolic rate, moderate metabolic rate, high metabolic rate, very high metabolic rate). The examples given in annex A, table A.1, include short rest pauses and illustrate the classification.

4.2 Table for the estimation of metabolic rate by occupations

Annex B, table B.1 shows the metabolic rate for some different occupations. The values are mean values for the whole working time, but without considering longer rest pauses, for example, lunch time. Significant variation may arise due to differences in technology, work elements, work organization, etc.

4.3 Tables for the estimation of metabolic rate by task-components

The metabolic rate of a man at work may be estimated by adding its various components. An inspection of the work place is usually necessary for this purpose.

The metabolic rate is analytically determined by adding the values of the following:

a) basal metabolic rate;

b) the component for body posture;

c) the component for type of work;

d) the component for body motion related to work speed.

The basal metabolic rate is the metabolic rate of a person lying down at rest under defined conditions.

The basal metabolic rate (BM) is a function of weight, height, age and sex. As these factors have little influence on BM, values of 44 W/m^2 for men and 41 W/m^2 for women can be used as a good approximation. In order to give comparable values, the values in this International Standard refer to a standard person, defined in annex C, table C.1.

In annex D, table D.1 gives the metabolic rate for body posture, table D.2 the metabolic rate for different types of work and table D.3 the metabolic rate for body motion related to work speed. Tables D.4 and D.5 give some examples of the use of this method.

4.4 Table indicating the metabolic rate for typical activities

Values of metabolic rate may be obtained from annex E, table E.1. These values are based on measurements.

4.5 Metabolic rate of a work cycle

To determine the overall metabolic rate of a work cycle it is necessary to carry out a time and performance study which includes a detailed description of the work. This involves classifying each activity, and taking account of factors such as the duration of each activity, the distances walked, heights climbed, weights manipulated, the number of actions carried out, etc.

The metabolic rate for a work cycle can be determined from the metabolic rate of the respective activity and the respective duration from the equation

$$M = \frac{1}{T} \sum_{i=1}^{n} M_i t_i \qquad \ldots (1)$$

where

M is the average metabolic rate of the work cycle, in watts per square metre;

M_i is the metabolic rate of the respective activity, in watts per square metre;

T is the duration, in seconds, of the considered work cycle;

t_i is the duration, in seconds. of the respective activity.

Annex F gives an example.

4.6 Requirements for the application of metabolic rate tables

4.6.1 Standardization of values

Values have been standardized with respect to the standard person defined in annex C to allow a comparison of values from different sources.

This is necessary for particular activities which require a movement associated with the body weight, for example walking upwards or lifting weights.

4.6.2 Variation of values

The values indicated vary within certain limits due to the influence of the following factors:

a) work technique;

b) work speed;

c) differences between the work equipment.

For the same work and under the same working conditions the metabolic rate can vary from person to person by about ± 5 %.

For someone used to the activity, the variation is about 5 % under laboratory conditions. Under field conditions, i.e. when the activity to be measured is not exactly the same from test to test, a variation up to 20 % or more can be expected.

4.6.3 Influence of climate

The metabolic rates given in this International Standard apply to moderate thermal environments. In a hot or cold environment the metabolic rate may increase.

In hot conditions a maximum increase of 5 W/m to 10 W/m^2 may be expected due to increased heart rate and sweating.

In cold conditions a maximum increase of up to 200 W/m^2 may be expected when shivering occurs. The wearing of heavy clothing will also increase metabolic rate.

4.6.4 Influences of the length of rest periods and work

Tables D.1 to D.5 and table E.1 (see 4.3 and 4.4) cannot be applied to an intermittent sequence of short activities and longer rests because this leads to higher levels of metabolic rate. The limits are shown in figure 1 where the hatched area shows the region in which the tables (see 4.3 and 4.4) cannot be used. Figure 1 only applies when the muscles are completely relaxed during a rest period.

Example I (see figure 1) shows a work rhythm of 8 min of resting time to 1 min of working time. In this case the metabolic rate tables (see 4.3 and 4.4) cannot be used. For activities showing a proportion of working time within the white field, as shown in example 2, the tables can be used safely.

As an increase in the metabolic rate due to the Simonson Effect depends on the type of work and the muscle groups used, further information on this problem is not given on account of its complexity.

4.6.5 Interpolation of the values

Interpolation of metabolic rate values is possible. Where working speeds differ from those given in the tables (see 4.3 and 4.4), conversion is only possible within a range of ± 25 % of the indicated speed.

5 Measurement of metabolic rate

5.1 Direct determination of metabolic rate

The methods of measurement described below were checked in many field studies and laboratory analyses; other methods have to be verified by the collected data using this method.

5.1.1 Methods of measurement

The metabolic rate can be determined by two principal methods:

— partial method;

— integral method.

The partial method shall be used for light and moderately heavy work, the integral method shall be used for heavy work of short duration. Different methods have to be used for the following reasons. In the case of light and moderately heavy work the oxygen uptake reaches the oxygen requirement after a short period of work. The oxygen uptake reaches a steady state and equals the oxygen requirement. In the case of heavy work, oxygen requirement is above the long-term limit of aerobic power and, in the case of very heavy work, above the maximal aerobic power. During heavy work, oxygen uptake cannot reach oxygen requirement. The oxygen deficit is balanced after work ceases. Thus, the measurement includes the working and the subsequent resting period. The integral method should be used for an oxygen consumption of more than 60 litres of oxygen per hour (60 l O_2/h), equivalent to 1 litre of oxygen per minute.

Figure 2 shows the procedure followed using the partial method. The work begins first without collecting any expired air.