

Evaluation of cold environments — Determination of required clothing insulation (IREQ)

ICS 13.180; 61.020

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National foreword

This Draft for Development is the English language version of ENV ISO 11079:1998.

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It is being issued in the Draft for Development series of publications and is of a provisional nature because further information about its use is required. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion into a European Standard. A review of this publication will be initiated 2 years after its publication by the European organization so that a decision can be taken on its status at the end of its three-year life. The commencement of the review period will be notified by an announcement in *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European Standard, to extend the life of the prestandard or to withdraw it. Comments should be sent in writing to the Secretary of BSI Subcommittee PH/9/1, Thermal environments, at 389 Chiswick High Road, London W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ENV ISO title page, page 2, the ISO TR title page, pages ii to iv, pages 1 to 28 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This Draft for Development, having been prepared under the direction of the Health and Environment Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 May 1999

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Descriptors: See ISO document

English version

Evaluation of cold environments — Determination of required clothing insulation (IREQ)

(ISO/TR 11079:1993)

Evaluation des ambiances froides —
Détermination de l'isolement requis des
vêtements
(ISO/TR 11079:1993)

Bewertung von Kälteumgebungen —
Bestimmung der erforderlichen Isolation der
Bekleidung (IREQ)
(ISO/TR 11079:1993)

This European Prestandard (ENV) was approved by CEN on 30 November 1997 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard.

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European Committee for Standardization
Comité Européen de Normalisation
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Foreword

The text of the International Standard from Technical Committee ISO/TC 159 “Ergonomics” of the International Organization for Standardization (ISO) has been taken over as an European Prestandard by 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 July 1998, and conflicting national standards shall be withdrawn at the latest by July 1998.

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

Endorsement notice

The text of the International Standard ISO/TR 11709:1993 has been approved by CEN as a European Standard without any modification.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

TECHNICAL
REPORT

ISO
TR 11079

First edition
1993-12-15

**Evaluation of cold environments —
Determination of required clothing
insulation (IREQ)**

*Évaluation des ambiances froides — Détermination de l'isolement requis
des vêtements*



Reference number
ISO/TR 11079:1993(E)

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Descriptors: Ergonomics, operating areas, work safety, clothing, thermal insulation, human body, thermal comfort, tests, cold weather tests, determination, thermal stress, temperature measurements.

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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard (“state of the art”, for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11079, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Sub-Committee SC 5, *Ergonomics of the physical environments*.

A series of International Standards related to the assessment of thermal environments are being produced within the framework of ISO/TC 159/SC5. For cold environments there are few methods available, insufficient experimental support and limited practical experience. More experimental work is needed to validate and further elaborate the methods contained in this Technical Report before there is a basis for the development of an International Standard.

This document is being issued in the type 2 Technical Report series of publications (according to subclause **G.4.2.2** of part 1 of the ISO/IEC Directives, 1992) as a “prospective standard for provisional application” in the field of assessment of thermal environments because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than two years after its publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

Annex A and Annex B form an integral part of this Technical Report. Annex C, Annex D, Annex E, Annex F and Annex G are for information only.

Introduction

Wind-chill is commonly encountered in cold climates, but low temperatures first of all endanger body heat balance. By proper adjustment of clothing, man can often control and regulate body heat loss to balance a change in the ambient climate. The method presented here is therefore based on the evaluation of the clothing insulation required to maintain in equilibrium the thermal balance of the body. The heat balance equation used takes into account the most recent scientific findings concerning heat exchanges at the surface of the skin as well as the clothing.

1 Scope

This Technical Report proposes methods and strategies to assess the thermal stress associated with exposure to cold environments. They apply to continuous, intermittent and occasional exposure and in both indoor and outdoor work. Specific effects associated with certain meteorological phenomena (e.g. precipitation) are not covered and should be assessed by other methods.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report 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 7726:1985, *Thermal environments — Instruments and methods for measuring physical quantities*.

ISO 7730:1984, *Moderate thermal environments — Determination of the PMV and PPD indices and specification of the conditions for thermal comfort*.

ISO 8996:1990, *Ergonomics — Determination of metabolic heat production*.

ISO 9920:—, *Ergonomics of the thermal environment — Estimation of the thermal insulation and evaporative resistance of a clothing ensemble*¹⁾.

¹⁾ To be published.

3 Symbols and abbreviations

A_{du}	body surface area, in square metres (m ²)
A_r	body surface area partaking in radiation heat exchange, in square metres (m ²)
C	convective heat exchange, in watts per square metre (W/m ²)
c_e	latent heat of evaporation, in joules per kilogram
c_p	specific heat of dry air at constant pressure, in joules per kilogram of dry air
C_{res}	respiratory convective heat exchange, in watts per square metre (W/m ²)
DLE	duration limited exposure, in hours (h)
E	evaporative heat exchange by sweating, in watts per square metre (W/m ²)
E_{res}	respiratory evaporative heat exchange, in watts per square metre (W/m ²)
f_{cl}	ratio of surface area of the clothed body to the surface area of the nude body, dimensionless
h_c	convective heat transfer coefficient, in watts per square metre degree Celsius (W/m ² ·°C)
h_r	radiation heat transfer coefficient, in watts per square metre degree Celsius (W/m ² ·°C)
I_a	boundary air layer insulation, in square metre degrees Celsius per watt (m ² ·°C/W)
I_{cl}	basic clothing insulation, in square metre degrees Celsius per watt (m ² ·°C/W)
I_{clr}	resultant clothing insulation, in square metre, degrees Celsius per watt (m ² ·°C/W)
I_T	total insulation of clothing and boundary air layer, in square metre degrees Celsius per watt (m ² ·°C/W)
I_{Tr}	resultant total insulation, in square metre degrees Celsius per watt (m ² ·°C/W)
i_m	Woodcock permeability index, dimensionless
IREQ	required clothing insulation, in square metre degrees Celsius per watt (m ² ·°C/W)

$IREQ_{min}$	minimal required clothing insulation, in square metre degrees Celsius per watt ($m^2 \cdot ^\circ C/W$)
$IREQ_{neutral}$	neutral required clothing insulation, in square metre degrees Celsius per watt ($m^2 \cdot ^\circ C/W$)
K	conductive heat exchange, in watts per square metre (W/m^2)
M	metabolic power, in watts per square metre (W/m^2)
p_a	ambient water vapour pressure, in kilopascals (kPa)
p_{ex}	saturated water vapour pressure at expired air temperature, in degrees Celsius ($^\circ C$)
p_{sk}	water vapour pressure at skin temperature, in kilopascals (kPa)
p_{sks}	saturated water vapour pressure at skin temperature, in kilopascals (kPa)
Q	body heat gain or loss, in watt hours per square metre ($W \cdot h/m^2$)
Q_{lim}	limit value for Q , in watt hours per square metre ($W \cdot h/m^2$)
R	radiation heat exchange, in watts per square metre (W/m^2)
R_T	resultant evaporative resistance of clothing and boundary air layer, in square metre kilopascals per watt ($m^2 \cdot kPa/W$)
RT	recovery time, in hours (h)
S	rate of change in body heat content, in watts per square metre (W/m^2)
t_a	ambient air temperature, in degrees Celsius ($^\circ C$)
t_{ch}	chilling temperature, in degrees Celsius ($^\circ C$)
$\bar{t}_{cl}$	clothing surface temperature, in degrees Celsius ($^\circ C$)
t_{ex}	expired air temperature, in degrees Celsius ($^\circ C$)
t_o	operative temperature, in degrees Celsius ($^\circ C$)
$\bar{t}_r$	mean radiant temperature of the environment, in degrees Celsius ($^\circ C$)
t_{sk}	local skin temperature, in degrees Celsius ($^\circ C$)
$\bar{t}_{sk}$	mean skin temperature, in degrees Celsius ($^\circ C$)
V	ventilation rate, in kilograms per second (kg/s)
v_a	air velocity, in metres per second (m/s)

v_{ar}	relative air velocity, in metres per second (m/s)
W	effective mechanical power, in watts per square metre (W/m^2)
w	skin wettedness, the equivalent fraction of the skin surface which can be considered as fully wet, dimensionless
W_a	humidity ratio of inhaled air, in kilograms of water per kilogram of dry air
W_{ex}	humidity ratio of exhaled air, in kilograms of water per kilogram of dry air
WCI	wind chill index, watts per square metre (W/m^2)

4 Principles of methods for evaluation

Cold stress is suggested to be evaluated in terms of both general cooling of the body and local cooling of particular parts of the body (e.g. extremities and face).

For general cooling, an analytical method is presented in clause 5 for the evaluation and interpretation of the thermal stress. It is based on a calculation of the body heat exchange and of the required clothing insulation (IREQ) for the maintenance of thermal equilibrium.

For local cooling, several methods are proposed in clause 6 for the evaluation of local thermal effects, e.g. cold injury or cold hands.

The scientific basis of each of the proposed methods in this Technical Report can be found in the relevant publications cited in Annex G.

5 General cooling

A general equation for body heat balance is defined. In this equation, clothing thermal properties, body heat production and physical characteristics of the environment are the determinant factors. The equation is solved for the required clothing insulation (IREQ) for maintained heat balance under specified criteria of physiological strain. As there is an upper limit for the amount of insulation clothing can provide, a duration limited exposure (DLE) is calculated for the existing clothing insulation on the basis of acceptable levels of body cooling. Detailed equations, coefficients and criteria are proposed in Annex A and Annex B.

The method involves the following steps, outlined schematically in Figure 1:

- measurements of the thermal parameters of the environment;
- determination of activity level (metabolic rate);