
**Ergonomics of the thermal
environment — Methods for the
assessment of human responses to
contact with surfaces —**

**Part 3:
Cold surfaces**

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*Ergonomie des ambiances thermiques — Méthodes d'évaluation de la
réponse humaine au contact avec des surfaces —*

*ISO 13732-3:2005
Partie 3: Surfaces froides*

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Foreword

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The main task of technical committees is to prepare International Standards. 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.

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.

ISO 13732-3 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

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ISO 13732 consists of the following parts under the general title *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces*:

- *Part 1: Hot surfaces*
- *Part 2: Human contact with surfaces at moderate temperature* [Technical Specification]
- *Part 3: Cold surfaces*

For the purposes of this part of ISO 13732, the CEN annex regarding fulfilment of European Council Directives has been removed.

Contents

	page
Foreword.....	v
Introduction.....	vi
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Principles for risk assessment.....	2
5 Threshold data.....	4
6 Risk assessment.....	9
7 Principles for establishing limit values.....	10
8 Principles for measures to minimize the risk.....	11
Annex A (informative) Scientific background.....	12
Annex B (informative) Extension of application.....	14
Annex C (informative) Thermal properties of selected materials.....	15
Annex D (informative) Examples of cold risk assessment.....	16
Annex E (informative) Protective measures.....	19
Bibliography.....	20

Foreword

This document (EN ISO 13732-3:2005) has been prepared by Technical Committee CEN/TC 122 "Ergonomics", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 159 "Ergonomics".

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 2006, and conflicting national standards shall be withdrawn at the latest by June 2006.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directives.

EN ISO 13732 consists of the following parts, under the general title "Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces"¹⁾:

- Part 1: Hot surfaces;
- Part 3: Cold surfaces.

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

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¹⁾ Part 2: has been published as ISO Technical specification ISO/TS 13732-2:2001 Human contact with surfaces at moderate temperature.

Introduction

This European Standard is a type B standard as stated in EN ISO 12100. The provisions of this document may be supplemented or modified by a type C standard.

NOTE For machines which are covered by the scope of a type C standard and which have been designed and built according to the provisions of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

Working with unprotected hands is often inevitable in the cold operation when a precision task is demanded. However the contact of bare skin with cold surfaces reduces skin temperature, causing acute effects such as discomfort, pain, numbness or frostbite. In addition repeated cold exposures with severe cooling of the skin may induce non-freezing cold injury (possible damage of nerves or vessels). Although the existing international standards are at hand for the assessment of the cold hazards involved, no standard concerns the special problems of contacting cold surfaces so far. Assessment of contact cooling is thus considered necessary.

To assess the risk of the cold injury, it is necessary to know the major factors affecting principally hand/finger cooling on cold surfaces. These factors involve:

- properties of the object surface;
- temperature of the cold surface and ambience;
- duration of contact between the skin and the surface;
- characteristics of hand/finger skin and the type and nature of the contact.

In practice, these factors are somewhat interacted and complicated. The type of contact material has an impact on the contact time at various cold temperatures. Thus, the contact time for the critical contact temperature limits on cold surfaces were empirically correlated with the major factors such as thermal penetration coefficient and surface temperature of the material, respectively. The statistically non-linear models (empirical models) based on the database of lower quartile (75 % protected) are able to estimate the finger/hand contact cooling of a large range of individuals on the cold surfaces.

This European Standard is designed to integrate all results obtained from the experimental research with both human fingers and an artificial finger. It outlines a guideline document for the specification of safe time limits of hand/finger contact with various cold surfaces.

1 Scope

This European Standard describes methods for the assessment of the risk of cold injury and other adverse effects when a cold surface is touched by bare hand/finger skin.

This standard provides ergonomics data to establish temperature limit values for cold solid surfaces. The values established can be used in the development of special standards, where surface temperature limit values are required.

The data of this standard will be applicable to all fields where cold solid surfaces cause a risk of acute effects: pain, numbness and frostbite.

The data are not limited to the hands but apply to human skin in general.

The standard is applicable to the healthy skin of adults (females and males). Considerations on the extension of applications are given in Annex B.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN ISO 12100-1:2003, *Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and the following apply.

3.1

touchable surface

surface of a product, which can be touched by a person

3.2

surface temperature

T_s

temperature of a material surface in °C

3.3

critical contact temperature

T_c

contact temperature at which defined skin response criteria are elicited in °C

3.4

contact period

D

duration during which contact of the skin with the surface takes place in s

3.5

thermal inertia

product of density (ρ), thermal conductivity (K) and specific thermal capacity (c) of a material

**3.6
contact factor**

F_c
thermal penetration coefficient, computed as square root of the thermal inertia

NOTE The mathematical definition is: $F_c = \sqrt{\rho \cdot K \cdot c}$.
where
 ρ is the density of a material;
 K is the thermal conductivity of a material;
 c is the thermal capacity of a material.

**3.7
percentile**

percentage of population of which specific characteristics fall below or above a given value in a cumulative distribution

[EN ISO 11064-4]

4 Principles for risk assessment

4.1 General

In order to assess the risk of cold injury and other effects, the following steps (4.2 to 4.8) shall be carried out.

4.2 Identification of cold touchable surfaces

All essential information concerning the cold touchable surfaces of the object shall be gathered. This shall include the objects attributes:

- a) accessibility of the surface;
- b) rough estimation of surface temperatures (above or below 0 °C);
- c) material and texture of the cold surface;
- d) all operating conditions of the object where contact with the cold surface is needed (including the worst case).

4.3 Task observation and analysis

According to the activities and tasks required, all necessary information concerning the contact with the cold surface shall be collected, by observation or analysis. Particular attention should be paid to possible intentional and unintentional contact with cold surfaces. The type and nature of the contact shall be identified from the task observation and analysis:

- a) cold surfaces which are or can be touched;
- b) intentional or unintentional touching;
- c) frequency of intentional touching;
- d) probability of unintentional touching;
- e) duration of contact with the cold surface;
- f) contacting area;
- g) contacting force.

4.4 Classification of contact with a cold surface

4.4.1 General

The type of contact is classified according to the following two categories:

4.4.2 Finger touching

Subjects contact a defined material during a short period (up to 120 s). The contact area is small (only finger pad).

4.4.3 Hand gripping

Subjects grip an object of defined material. Gripping is applied constantly for a longer period (up to 1 200 s).

4.5 Measurement of surface temperature

The surface temperatures shall be measured on those parts of the object where skin contact with the surface can occur.

The measurement shall be carried out under real operating conditions of the object by thermocouples. The accuracy of the instrument shall be $\pm 0,5$ °C in a range from $- 25$ to $+ 5$ °C and ± 1 °C below $- 25$ °C (see ISO 7726:2001 and [4]).

NOTE The results of the measurement of the surface temperature can only be compared with the threshold values of Clause 5, if they are realized using the same physical measurement principle which was used for the determination of the threshold values of Clause 5. The application of a different measuring principle, e.g. a radiation thermometer, can lead to other results which are not comparable with the threshold values.

4.6 Period

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The contact period of bare skin with a cold surface can be measured or estimated according to values in Table D.1.

4.7 Classification of type of effect on skin during contact

4.7.1 General

Type of effect shall be determined according to the following criteria.

4.7.2 Frostbite

The effect is predicted from a drop in contact temperature to below 0 °C, at which the contacting skin tissue will freeze.

4.7.3 Numbness

The effect is predicted from a drop in contact temperature to around 7 °C, at which sensory receptors of contacting skin will be blocked and numbness will occur.

4.7.4 Pain

The effect is predicted from a drop in contact temperature to around 15 °C, at which a subjective sensation of pain at the contacting skin will be experienced.

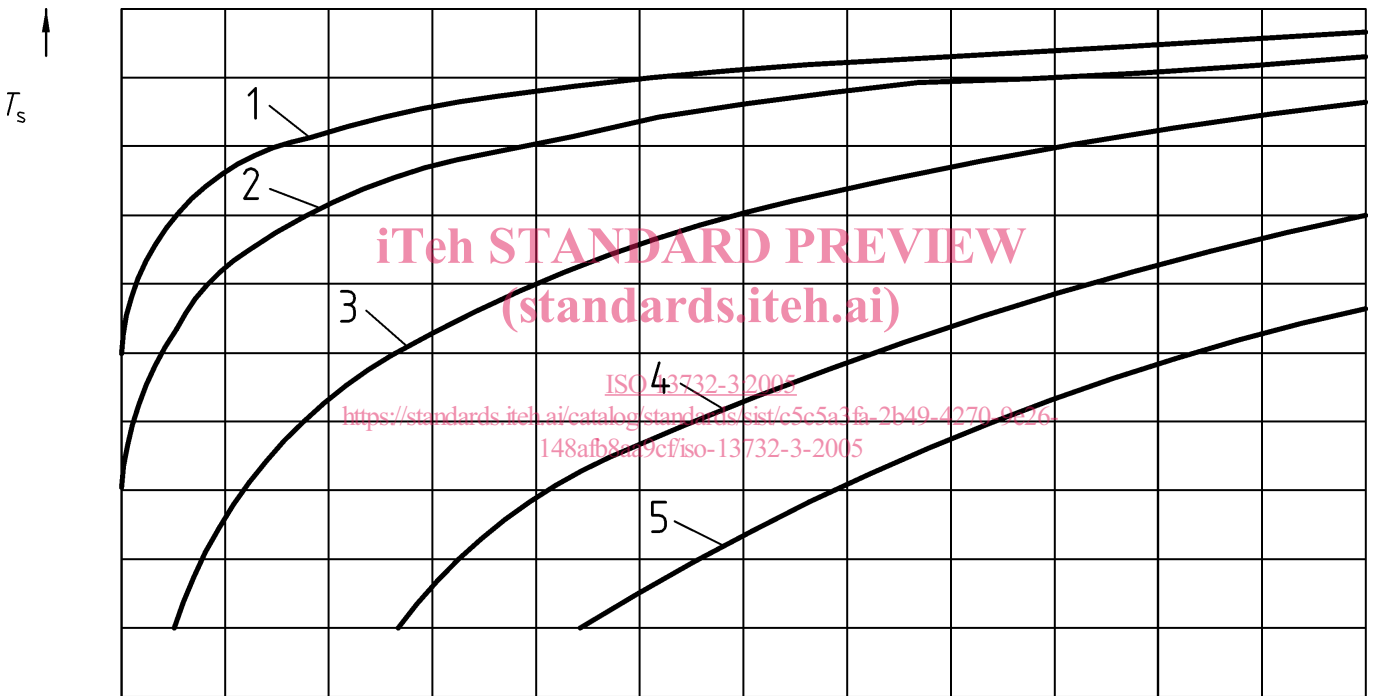
4.8 Risk evaluation

On the basis of this information the data in Clause 5 shall be used for final evaluation to establish if there is a risk for the selected type of effect to occur. An estimate of the risk is made on the basis of surface temperature and contact period specified in 5.2 and 5.3.

5 Threshold data

5.1 General

This Clause provides surface temperature data for cooling thresholds from the ergonomics database. Figure 1 shows the principal relation between material, time and temperature for skin in contact with a cold surface. Below the curve of each material there is a risk of an adverse effect of skin cooling. This figure is presented for guidance only of the temperature/time relationship and the relative effects of different materials. The quantitative information is provided in the subsequent Clauses.



Key					
1	Aluminium	3	Stone	5	Wood
2	Steel	4	Nylon		
D	Contact period	T_s	Surface temperature		

Figure 1 — Principal relationship between material, duration and temperature for skin in contact with a cold surface

The thermal properties of the mentioned materials (Aluminium, Steel, Stone, Nylon, and Wood) and other selected materials are given in Annex C.

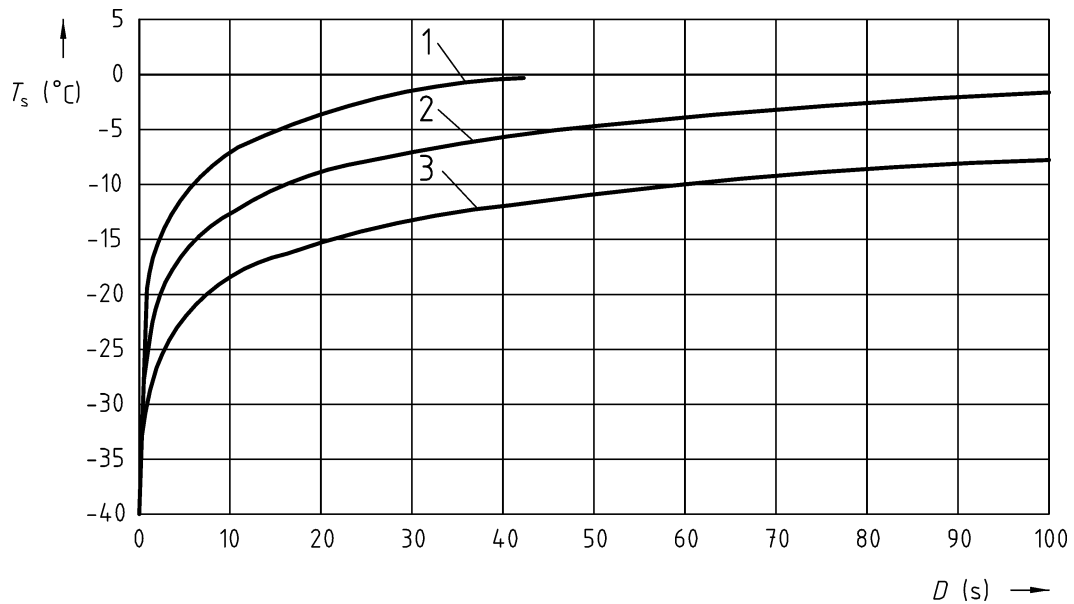
5.2 Finger touching

5.2.1 General

Thresholds for finger skin touching are specified in 5.2.2 (Figures 2 to 4).

5.2.2 Thresholds for finger contacting cold surfaces

The freezing (frostbite) threshold values of finger touching three cold surfaces (aluminium, steel and stone) are shown in Figure 2.



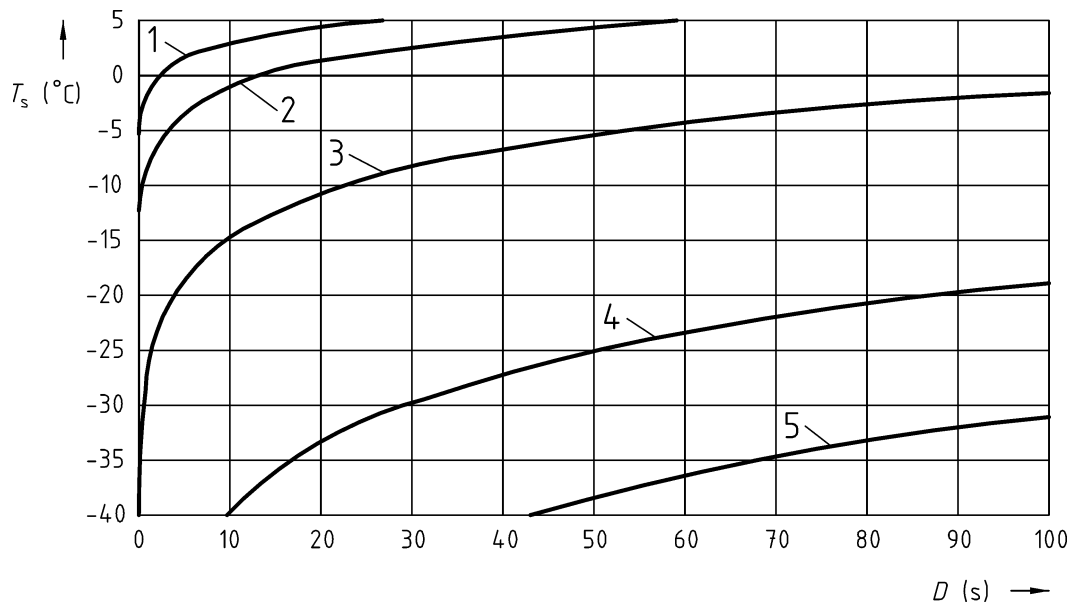
Key

- 1 Aluminium
- 2 Steel
- 3 Stone

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Figure 2 — Frostbite threshold as function of contact period (finger touching)

The numbness thresholds for finger touching the five materials are indicated in Figure 3.



Key

- 1 Aluminium
- 2 Steel
- 3 Stone
- 4 Nylon
- 5 Wood

Figure 3 — Numbness threshold as function of contact period (finger touching)

The pain thresholds for finger touching different materials are indicated in Figure 4.