ISO 16976-5:2023(E)

Date: 2023-~~01-12~~xx

ISO/TC 94/SC 15~~/WG 5~~

Secretariat: SA

Respiratory protective devices — Human factors — Part 5: Thermal effects

Appareils de protection respiratoire — Facteurs humains — Partie 5: Effets thermique

Style Definition: Heading 1: Indent: Left: 0 pt, First line: 0 pt, Tab stops: Not at 21.6 pt

Style Definition: Heading 2: Font: Bold, Tab stops: Not at 18 pt

Style Definition: Heading 3: Font: Bold

Style Definition: Heading 4: Font: Bold

Style Definition: Heading 5: Font: Bold

Style Definition: Heading 6: Font: Bold

Style Definition: ANNEX

Style Definition: AMEND Terms Heading: Font: Bold

Style Definition: AMEND Heading 1 Unnumbered: Font: Bold

Formatted: French (Switzerland)

Formatted: French (Switzerland)

Formatted: French (Switzerland)

ISO copyright office

Ch. de Blandonnet 8 • CP 401

CH-1214 Vernier, Geneva, Switzerland

Tel. + 41 22 749 01 11

Fax + 41 22 749 09 47

copyright@iso.org

~~www.iso.org~~

www.iso.org

Commented [eXtyles1]: The reference is to a withdrawn standard which has been replaced

ISO 20344, Personal protective equipment — Test methods for footwear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Contents

Page

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~~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~~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~~www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Personal protective equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This first edition of ISO 16976-5 cancels and replaces the second edition (ISO/TS 16976-5:2020), which has been technically revised.

The main changes are as follows:

— requirements more specified.

A list of all parts in the ISO/TS 16976 series can be found on the ISO website.

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~~www.iso.org/members.html.

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

Introduction

For an appropriate design, selection and use of respiratory protective devices, basic physiological demands of the user should be considered. The function of a respiratory protective device, the way it is designed and used and the properties of its material can have a thermal effect on the human body.

This document belongs to a series of documents providing basic physiological and anthropometric data on humans. It contains information about thermal effects associated with wearing respiratory protective devices.

Respiratory protective devices — Human factors — Part 5: Thermal effects

1 Scope

This document is one part of a series of ~~Technical Specifications~~International Standards that provide information on factors related to human anthropometry, physiology, ergonomics and performance for the preparation of standards for design, testing and use of respiratory protective devices. This document contains information related to thermal effects of respiratory protective devices on the human body. In particular information is given for:

— temperatures of surfaces associated with discomfort sensation and harmful effects on human tissues;

— thermal effects of breathing gas temperatures on lung airways and tissues;

— effects of breathing gas temperature and humidity on respiratory heat exchange;

— effects of respiratory protective devices on overall body heat exchange.

The information represents data for adult healthy men and women in the age 20 years to 60 years.

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.

~~<std>~~ISO 11079, *Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects*~~</std>~~

~~<std>~~ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*~~</std>~~

~~<std>~~ISO 13732-3, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 3: Cold surfaces*~~</std>~~

~~<std>ISO 16972, *Respiratory protective devices — Vocabulary and graphical symbols*</std>~~

ISO 16972, *Respiratory protective devices — Vocabulary and graphical symbols*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16972 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

Formatted: Left
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

— IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

3.1.1
clo
unit for the expression of the thermal insulation of clothing

Note 1 to entry: 1 clo is equal to 0,155 K m²/W.

3.1.2
insulation required
IREQ
required clothing insulation for the preservation of body heat balance at defined levels of physiological strain

[SOURCE: ISO 11079:2007, 3.1.1]

Note 1 to entry: As determined according to ISO 11079.

3.1.3
predicted heat strain
PHS
analytical determination and interpretation of the thermal stress (in terms of water loss and rectal temperature) experienced by an average person in hot environments

Note 1 to entry: As determined according to ISO 7933.

Commented [eXtyles4]: The term "insulation required" has not been used anywhere in this document

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

3.2 Abbreviated terms and symbols

IREQ	Insulation required
PHS	Predicted heat strain
PPE	Personal protective equipment
PMV	Predicted mean vote
PPD	Predicted percentage dissatisfied
RPD	Respiratory protective device
SCBA	Self-contained breathing apparatus
T_s	Surface temperature (temperature of the surface contacted by skin)
T_a	Ambient temperature (temperature of the air surrounding the body or inhaled)
T_c	Contact temperature (temperature of the interface between skin and contacted surface)

4 Local thermal effects

4.1 General

The effects of heat and cold described in this document will vary according to individual sensitivity.

Notice should be taken of the assessment scales given in ISO 8996.

Formatted: Pattern: Clear
Formatted: Pattern: Clear

4.2 Effects on skin contact by the RPD

Heat transfer by conduction takes place via the hands when handling the equipment and via face, head and torso during the actual use of the equipment.

Parts of RPD are, by their very nature, in more or less direct contact with naked human skin, e.g. the face. In contact areas heat exchange will be affected. The magnitude of this effect is dependent on contact pressure, structure of surfaces, size of contact area, mass of material in contact, thermal conditions and thermal properties of materials in contact.

Materials used in RPD are mostly made of materials with low conductive heat transfer properties. Exceptions are metal parts, in particular, if they are not insulated.

In extreme hot or cold environments, the ambient conditions can heat or cool the RPD or parts of it, thereby increasing the risk of a thermal effect on the skin.

A risk assessment of contact cooling or heating of the bare skin shall be based on

— ISO 13732-1, for hot surfaces, and

— ISO 13732-3, for cold surfaces.

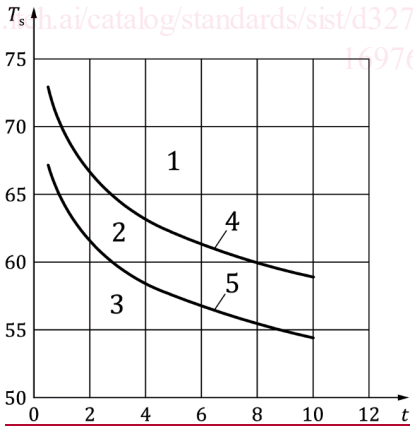
Exposure values and criteria used in the figures below are based on hand or body skin surface contacts. Face skin is likely to be more sensitive in particular to discomfort and more conservative values should be used.

4.3 Hot surfaces

ISO 13732-1 provides comprehensive information about the risk of bare skin contacting different types of materials at different temperatures. Figure 1 shows surface temperatures of polished aluminium metal that can cause skin burns. This condition appears to be the most severe case, but other metals such as steel and copper can be as harmful at similar or slightly higher temperatures. Other materials like plastic, glass and ceramics require considerably higher temperature to cause harm to bare skin.

For these materials the zone 3 “safe surface” in Figure 1 moves up to the line 4, i.e. upper limit.

~~16976-5_ed1fig1.EPS~~



Key

t time, in s

T_s surface temperature, in °C

1 zone 1 indicates a high risk of skin burn

2 zone 2 indicates a possible risk of skin burn

3 zone 3 indicates safe surface temperatures

4 upper limit

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

5 lower limit

Figure 1 — Surface temperature of polished aluminium metal that can cause skin burns

RPD is likely to be used for short duration timed in minutes and longer duration timed in hours. Table 1 indicates burn thresholds for contact periods of 1 min and longer for different materials (modified from ISO 13732-1). Values apply for contact areas that are less than 10 % of the body surface, so they should apply for most RPD.

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

Table 1 — Burn threshold for contact periods of 1 min and longer

Material	**1 min**	**10 min**	**8 h and longer**
	°C		
Uncoated metal	51		
Coated metal	51		
Ceramics, glass and stone materials	56	48	43
Plastics	60		
Wood	60		

4.4 Cold surfaces

ISO 13732-3 provides detailed information about the assessment of cooling effects on skin in contact with various types of cold surfaces. Information is given about five types of materials: aluminium, steel, stone, plastic and wood. For each of the materials three criteria for cooling are applied.

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

As with a hot surface contact with a small skin surface area with cold, metallic goods can rapidly cool the skin and eventually result in local frostbite. Figure 2 and 3 show cooling curves obtained with the fingertip touching surfaces of steel and aluminium at temperature of −20 °C, −30 °C and −40 °C. The contact temperature, T_c, which is likely to be very close to the skin surface temperature drops to below 0 °C within few seconds when touching the metallic surfaces (see Figure 2 and 3). The risk of developing local frostbite is highly probable.

Formatted: Pattern: Clear
Formatted: Pattern: Clear

Studies[6] have shown that:

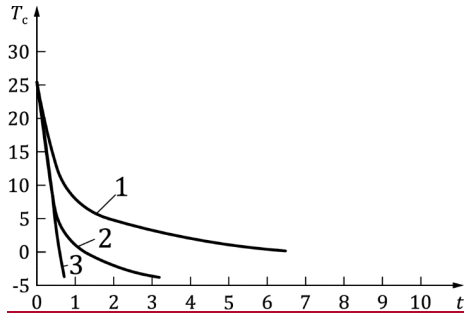
Formatted: Pattern: Clear

— Cooling to a skin temperature of 0 °C is associated with an imminent risk of tissue freezing “frostbite”.

— Cooling to a skin temperature of +7 °C is associated with the gradual development of numbness.

— Cooling to a skin temperature of +15 °C is associated with the experience of pain.

~~16976-5_ed1fig2.EPS~~



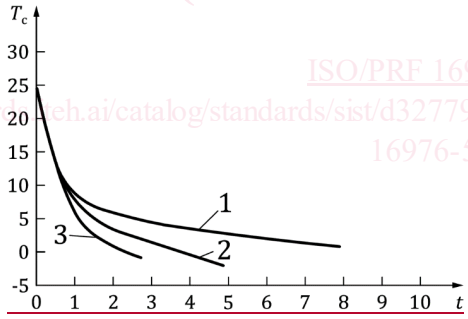
Key

t time, in s
T_c contact temperature, in °C
1 −20 °C
2 −30 °C
3 −40 °C

Figure 2 — Change in T_c of finger in contact with steel surfaces at temperatures of −20 °C, −30 °C and −40 °C

Formatted: Font: Not Bold
Formatted: Font: Not Bold

~~16976-5_ed1fig3.EPS~~



Key

t time, in s
T_c contact temperature, in °C
1 −20 °C
2 −30 °C
3 −40 °C

Figure 3 — Change in T_c of finger in contact with aluminium surfaces at temperatures of −20 °C, −30 °C and −40 °C

Formatted: Font: Not Bold
Formatted: Font: Not Bold

Figure 4 to Figure 6 show the surface temperature of a specific material that might cause the different type of cooling effects[6].

Formatted: Pattern: Clear
Formatted: Pattern: Clear
Formatted: Pattern: Clear

~~16976-5_ed1fig4.EPS~~