INTERNATIONAL STANDARD

**ISO 13732-1**

First edition
2006-09-01

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

## Part 1: Hot surfaces

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

*Partie 1: Surfaces chaudes*



Reference number
ISO 13732-1:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 13732-1 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 122, *Ergonomics*, 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).

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*

# Introduction

When human skin comes into contact with a hot solid surface, burns may occur. Whether or not they do depends on a number of factors, the most important of which are

— the temperature of the surface,

— the material of the surface,

— the period of contact between the skin and the surface,

— the structure of the surface, and

— the sensitivity of the human being who comes into contact with the surface (e.g. child or adult).

Other factors can also play a part but are of minor importance. In Annex A the scientific background is presented and in the Bibliography publications concerning the objective are listed.

This part of ISO 13732 contains a collection of temperature threshold values for burns when the skin is in contact with a hot solid surface (Clause 4). It also contains a method for the assessment of the risk of burning, i.e. the application of the provided ergonomics data within a risk assessment procedure (Clause 5). A further application of the data may be the specification of temperature limit values for hot surfaces. Such temperature limit values may be specified in product standards or in regulations in order to prevent human beings sustaining a burn when in contact with the surface of a hot product. Guidance on how to select reasonable temperature limit values for that purpose is given in Clause 7. For different products with the same risk of burning it is reasonable to establish identical surface temperature limit values. Therefore, this part of ISO 13732 provides the possibility of harmonizing such temperature limit values for all kind of products.

Touching a hot surface may take place intentionally, e.g. to operate an electrically or gas powered machine or tool, or unintentionally, when a person is near a hot object. The period of contact with the hot surface will be different if the object is touched intentionally than if it is touched unintentionally. Considering human reaction times and their distribution in the population, 0,5 s is the minimum applicable contact period for unintentional touching of a hot surface for healthy adults on an acceptable safety level. For intentional touching the minimum applicable contact period will be longer. For the application of this part of ISO 13732, it is essential to select a contact period which best represents the real circumstances when a hot product is touched. Guidance for such selection is given in Annex B.

The ergonomics data provided in this part of ISO 13732 are mainly based on scientific research and represent, as far as is known, the behaviour of the human skin when in contact with a hot surface. Some of the data (e.g. burn threshold data for very short contacts of 0,5 s) are not directly based on scientific research but are deduced by extrapolation of the known threshold curves or by reasonable conclusion using scientific results.

The temperature threshold values provided in this part of ISO 13732 are valid for burning the skin when in contact with hot surfaces. For the time being there are not sufficient scientific data available on the effects of discomfort and pain to for them to be included in this part of ISO 13732. Some data for pain can be derived from national standards (see Annexes A and the Bibliography). Research projects are planned for obtaining data for discomfort and pain. When the results of these projects are available, this part of ISO 13732 may be revised in order to also include discomfort and pain temperature threshold values. ISO 13732-2 deals also with discomfort.

This part of ISO 13732 does not provide burn data on the skin that comes into contact with liquids or gases.

NOTE With the exception of water there are no such data available up to now. For water and liquids with similar heat capacity and heat flow properties burn threshold values for bare metals can be chosen.

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

# Part 1: Hot surfaces



## 1 Scope

This part of ISO 13732 provides temperature threshold values for burns that occur when human skin is in contact with a hot solid surface.

It also describes methods for the assessment of the risks of burning, when humans could or might touch hot surfaces with their unprotected skin.

This part of ISO 13732 also gives guidance for cases where it is necessary to specify temperature limit values for hot surfaces; it does not set surface temperature limit values.

NOTE 1 Such temperature limit values can be specified in specific product standards or in regulations in order to prevent human beings sustaining burns when in contact with the hot surface of a product.

This part of ISO 13732 deals with contact periods of 0,5 s and longer.

It is applicable to contact when the surface temperature is essentially maintained during the contact (see 4.1).

It is not applicable if a large area of the skin (approximately 10 % or more of the skin of the whole body) can be in contact with the hot surface. Neither does it apply to skin contact of more than 10 % of the head or contact which could result in burns of vital areas of the face.

NOTE 2 In some cases, the results of contact with a hot surface can be more serious for the individual, for example:

— burns resulting in the restriction of airways;

— large burns (more than 10 % of the body surface) that can impair the circulation by fluid loss;

— heating of a large proportion of the head or whole body that could lead to unacceptable heat strain even in the absence of burning.

This part of ISO 13732 is applicable to the hot surfaces of all kind of objects: equipment, products, buildings, natural objects, etc. For the purposes of simplification, it mentions only products; nevertheless, it applies to all other objects as well.

It is applicable to products used in any environment, e.g. in the workplace, in the home.

It is applicable to hot surfaces of products that may be touched by healthy adults, children, elderly people and also by people with physical disabilities.

It does not provide data for the protection against discomfort or pain.

## 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).

ISO 7726:1998, *Ergonomics of the thermal environment — Instruments for measuring physical quantities*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**touchable surface**
surface of a product that can be touched by a person's skin

**3.2**
**surface temperature**
$T_s$
temperature of a material's surface

NOTE Surface temperature is expressed in degrees Celsius (°C).

**3.3**
**contact period**
$D$
duration of contact of the skin with the surface

NOTE Contact period is expressed in seconds (s).

**3.4**
**thermal inertia**
product of density ($\rho$), thermal conductivity ($\lambda$) and specific thermal capacity ($c$) of a material

**3.5**
**burn threshold**
surface temperature defining the boundary between no burn and a superficial partial thickness burn, caused by contact of the skin with this surface for a specified contact period

NOTE Burns are classified into three levels, depending on severity.

— superficial partial thickness burn:

in all but the most superficial burns, the epidermis is completely destroyed but the hair follicles and sebaceous glands as well as the sweat glands are spared.

— deep partial thickness burn:

a substantial part of the dermis and all sebaceous glands are destroyed and only the deeper parts of the hair follicles or the sweat glands survive.

— whole thickness burn:

the full thickness of the skin is destroyed and there are no surviving epithelial elements.

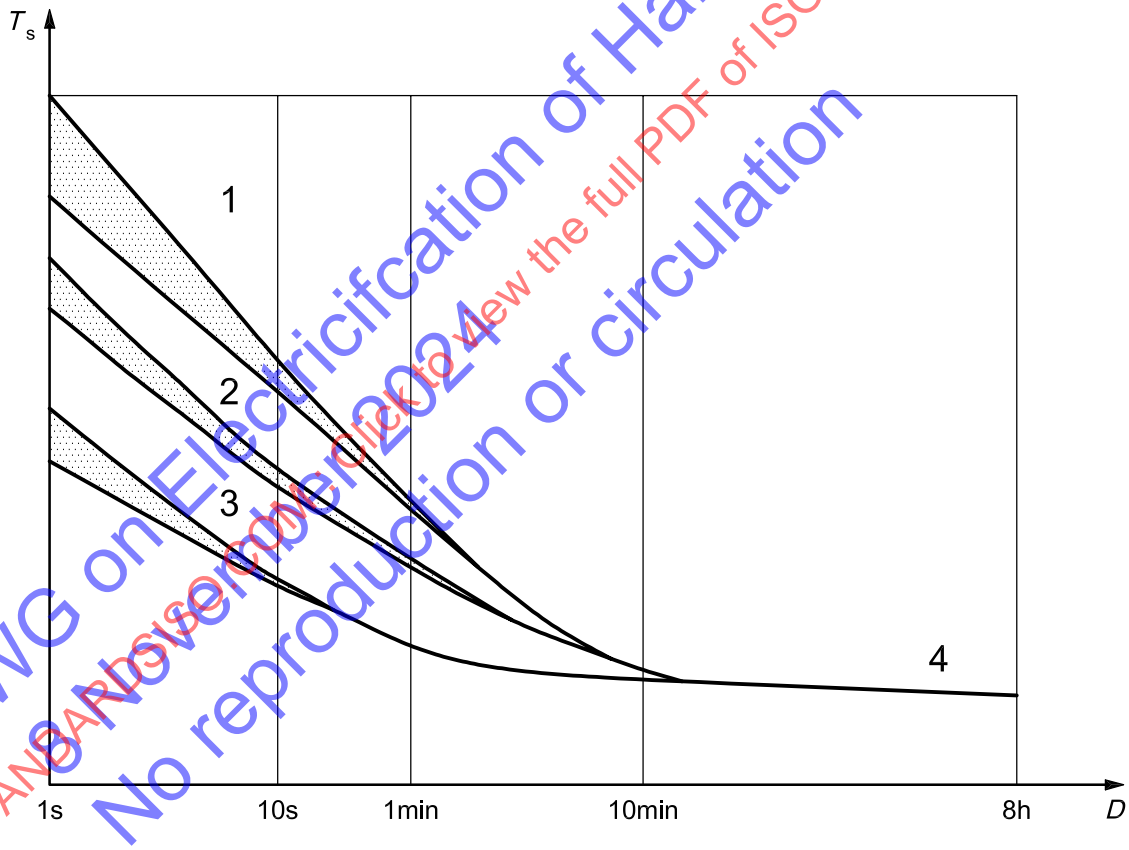
# 4 Burn thresholds

## 4.1 General

This clause provides surface temperature data for burn thresholds.

NOTE The occurrence of burning depends on the temperature of the skin and on the period of raised skin temperature. The connection between skin temperature, the period of its influence and occurrence of burning has been scientifically studied and is known (see Annex A). But it is not practicable by simple means to measure the temperature of the skin during its contact with the hot surface of a product. Therefore, in this part of ISO 13732 it is not the temperature values of the skin which are specified but the temperature values of hot surfaces of products which, when in contact with the skin, lead to burns (the burn thresholds). The temperature of a surface of a product is simply measurable by appropriate measuring facilities.

The surface temperatures which lead to burns during contact of the skin with a hot product depend on the material of which the product consists, and on the period of the contact of the skin with the surface. This relationship is presented in Figure 1, which shows this relationship for several groups of materials which have similar heat conductivity properties and therefore similar burn thresholds.




**Key**

$D$ contact period

$T_s$ surface temperature

1 plastics

2 ceramics

3 metals

4 burn threshold

**Figure 1 — Illustration of general relationship between burn threshold and contact period when hot surface is touched by skin**

A point on a burn threshold curve indicates, for a particular contact period, that surface temperature which lies between non-injury of the skin and the onset of a superficial partial thickness burn when the skin comes into contact with the hot surface. Surface temperature values lying below the curve in general do not lead to a burn. Surface temperature values lying above the curve will lead to a burn of the skin (see also Annex A).

The illustrative Figure 1 only serves to provide a better understanding and does not accurately represent the burn threshold data. The exact burn threshold values are to be taken from Figures 2, 5, 6 and 7 and Table 1.

For short contact periods the burn thresholds are not drawn as lines in the illustrative Figure 1 and the detailed Figures 2, 5, 6 and 7, but as spreads. This takes into account the fact that for short contact periods the knowledge of the temperature boundary between non-burning and the onset of burning is not complete. The burn threshold depends on several factors, including thickness of the skin at the touching point, moisture of the skin's surface (sweating), contamination of the skin (e.g. grease), touching force differences between the heat conductivity properties of materials which have been combined in one group, uncertainties of the scientific determination of the burn threshold values (see also Annex A). However, these influences are considered to be minor compared to the influence of the heat conductivity properties of the different material groups.

For longer contact periods the uncertainties are less than for short contact periods. So for long contact periods exact values for burn thresholds are specified. The differences in the values for different groups of materials also disappear for long contact periods.

The data given presumes that the surface temperature is essentially maintained during the contact period either by the mass of the product or by a heating source. These conditions will describe exposures which are in conformity with the worst case.

## 4.2 Burn threshold data

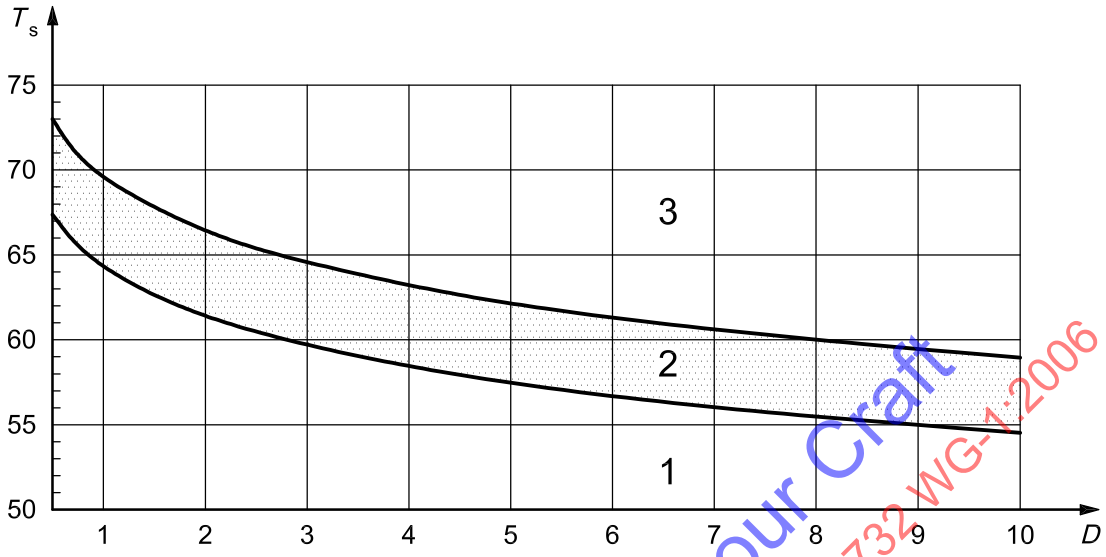
### 4.2.1 Burn thresholds for contact periods between 0,5 s and 10 s

#### 4.2.1.1 General

In the case of short contact (contact periods of 0,5 s to 10 s), the burn threshold spreads are not set in numbers but are reflected in graphs in relation to the contact period. The burn thresholds of materials with similar heat conductivity properties are combined to represent one spread.

#### 4.2.1.2 Uncoated metals

The burn thresholds presented in Figure 2 are valid for the smooth surfaces of uncoated metals. In the case of rough metal surfaces, however, the values may lie above those for smooth surfaces, but not more than 2 °C beyond the upper limit of the indicated burn threshold spread.




**Key**

$D$ contact period, s

$T_s$ surface temperature, °C

1 no burn

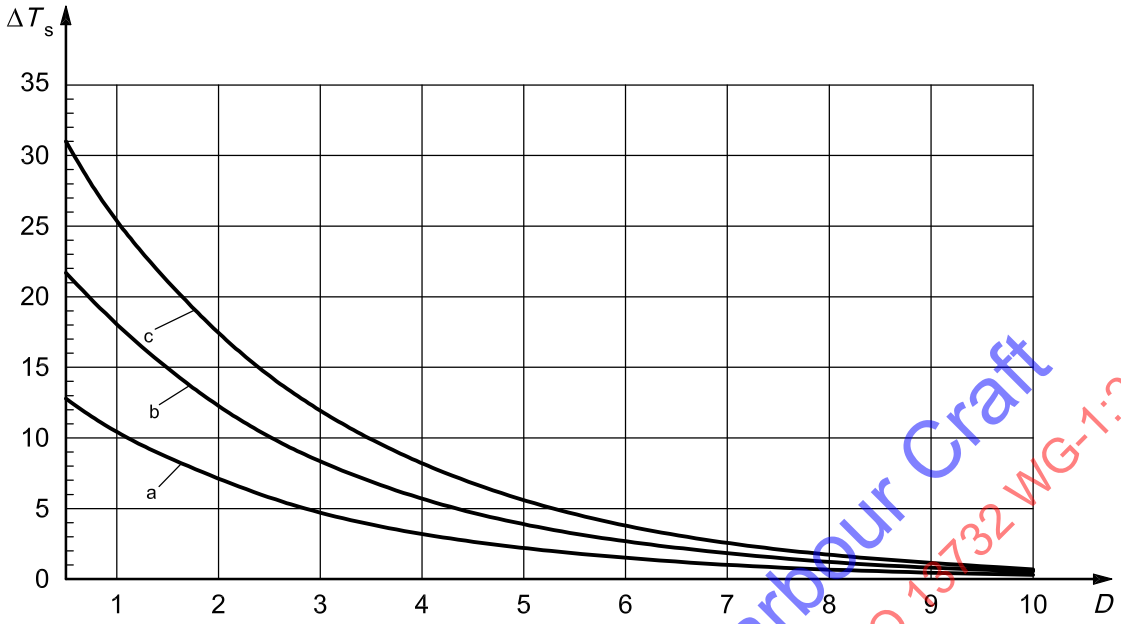
2 burn threshold

3 burn

**Figure 2 — Burn threshold spread when the skin in contact with hot, smooth surface made of bare (uncoated) metal**

#### 4.2.1.3 Coated metals

The values for the effect of coating a metal are shown in Figures 3 and 4. The values reflect the rise of the burn threshold above the burn threshold for uncoated metal. In order to obtain a burn threshold for coated metal, the value for the rise of the burn threshold in Figure 3 or 4 and the burn threshold for the uncoated metal in Figure 2 have to be added.




**Key**

$D$ contact period, s

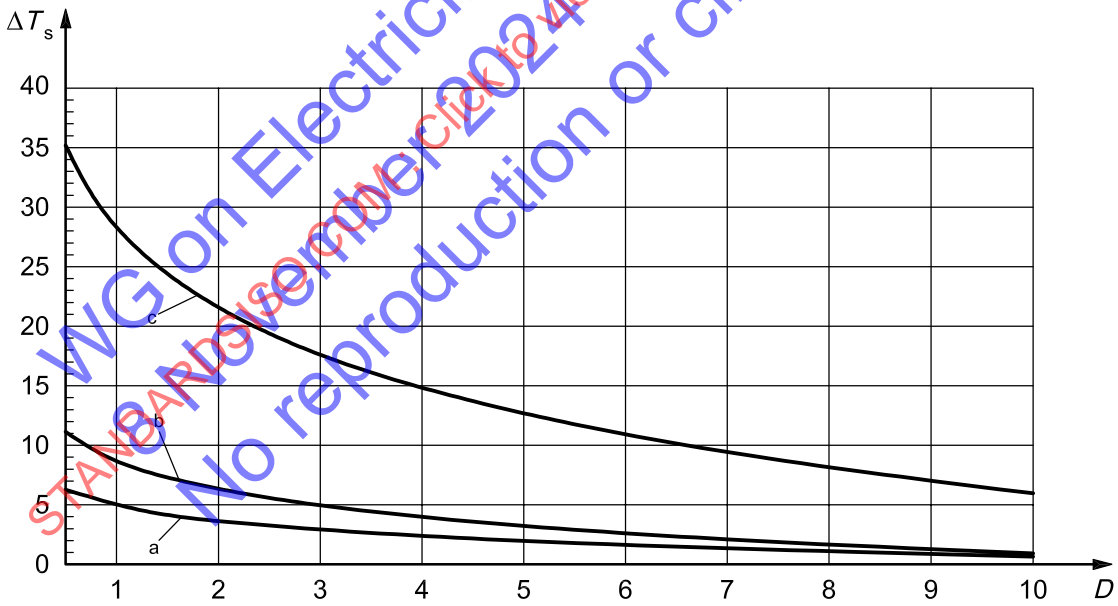
$\Delta T_s$ rise in surface temperature, °C

a 50 µm.

b 100 µm.

c 150 µm.

**Figure 3 — Rise in burn threshold spread from Figure 2 for metals coated by lac of 50 µm, 100 µm and 150 µm**




**Key**

$D$ contact period, s

$\Delta T_s$ rise in surface temperature, °C

a Enamel (160 µm)/powder (60 µm).

b Powder (90 µm).

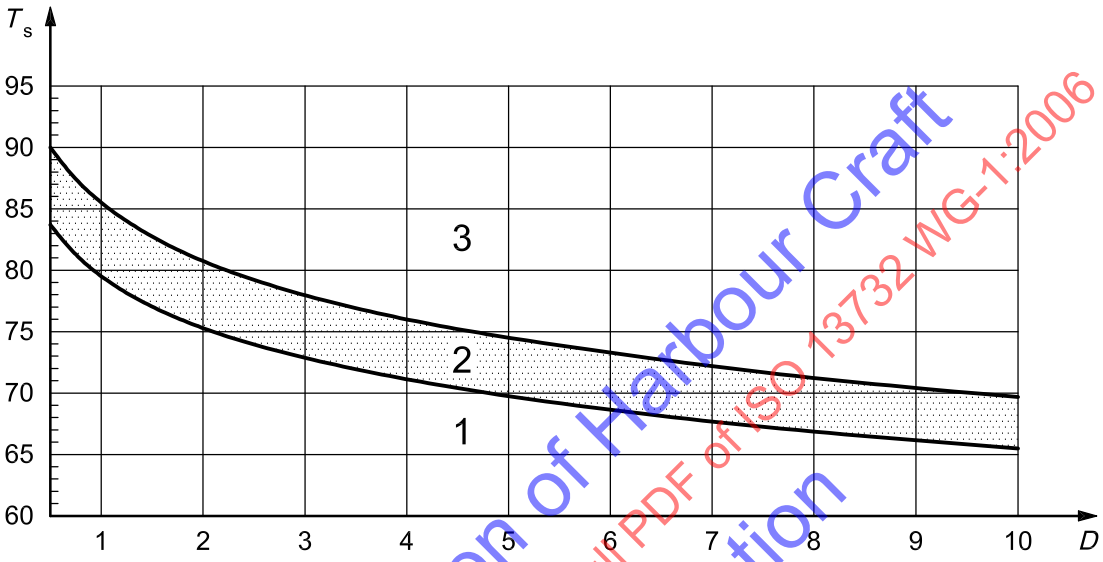
c Polyamide 11 or 12 (400 µm thickness).

**Figure 4 — Rise in burn threshold spread from Figure 2 for metals coated by powder (60 µm and 90 µm), enamel (160 µm) and polyamide 11 or 12 (400 µm thickness)**

#### 4.2.1.4 Ceramics, glass and stone materials

The burn threshold spread for ceramics, glass ceramics, glass, porcelain and stone materials (marble, concrete) is shown in Figure 5.

The burn thresholds for marble and concrete lie towards the lower limit of the spread. Burn thresholds for glass lie towards the upper limit of the spread.




**Key**

$D$ contact period, s

$T_s$ surface temperature, °C

1 no burn

2 burn threshold

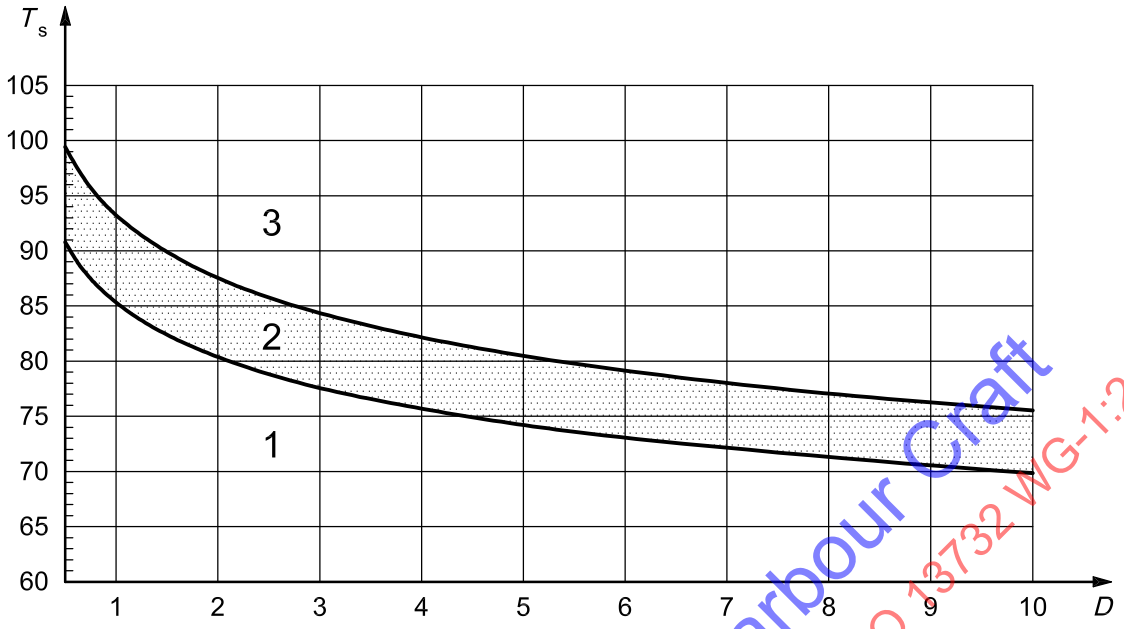
3 burn

**Figure 5 — Burn threshold spread when skin is contact with hot, smooth surface made of ceramics, glass and stone materials**

#### 4.2.1.5 Plastics

The burn threshold spread for plastics (polyamide, acrylglass, polytetrafluorethylene, duroplastic) is shown in Figure 6.

NOTE Plastics have very different levels of thermal conductivity, depending on chemical composition. The burn threshold spread for most solid plastics is indicated in Figure 6. However, for plastics with heat conductivity properties which differ markedly from those of the materials given here, the burn thresholds indicated cannot be used. For these materials, burn thresholds have to be calculated, estimated or measured according to Annex A.




**Key**

$D$ contact period, s

$T_s$ surface temperature, °C

1 no burn

2 burn threshold

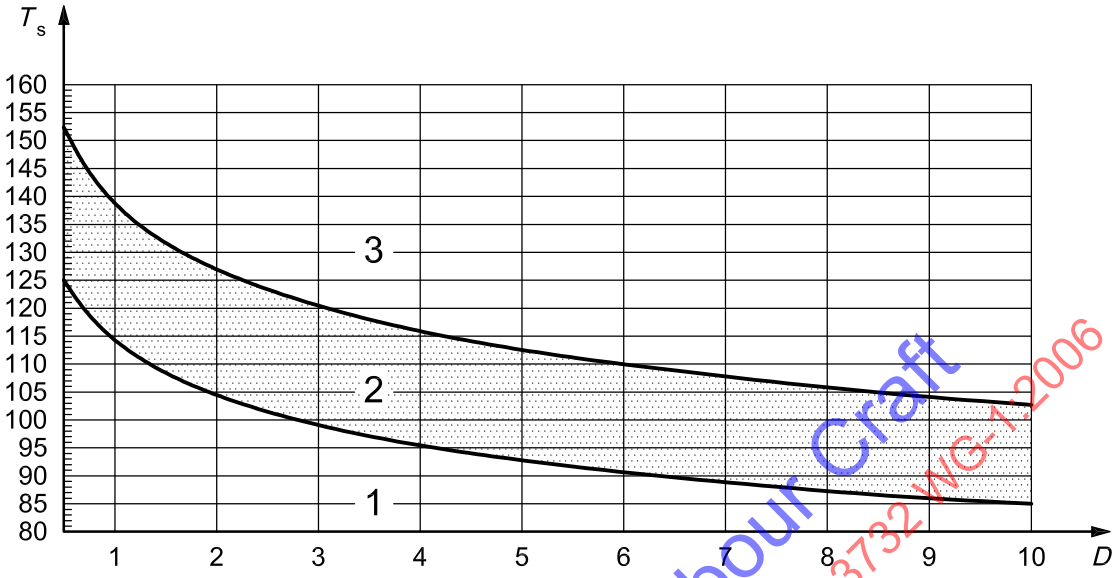
3 burn

**Figure 6 — Burn threshold spread when skin in contact with hot, smooth surface made of plastics**

#### 4.2.1.6 Wood

The burn threshold spread for wood is shown in Figure 7.

For soft woods with low moisture content the values at the upper limit of the spread are applicable. For hard woods with high moisture content the values at the lower limit of the spread are relevant.




**Key**

$D$ contact period, s

$T_s$ surface temperature, °C

1 no burn

2 burn threshold

3 burn

**Figure 7 — Burn threshold spread when skin in contact with hot, smooth surface made of wood**



### 4.2.2 Burn thresholds for contact periods between 10 s and 1 min

For contact periods between 10 s and 1 min, a linear interpolation can be made for the specific material between the lower and the upper border lines of the burn threshold spreads indicated in Figures 2 to 7 for a contact period of 10 s (see 4.2.1) and the value in Table 1 corresponding to the contact period of 1 min (see 4.2.3). So the burn threshold is obtained as a spread for contact periods near above 10 s. This spread focuses on a single value at a contact period of 1 min.

### 4.2.3 Burn thresholds for contact periods of 1 min and longer

Table 1 presents burn thresholds when a surface is touched for contact periods of 1 min and longer.

**Table 1 — Burn thresholds for contact periods of 1 min and longer**

| Material | Burn thresholds for contact periods of | | |
|---|---|---|---|
| | 1 min | 10 min | 8 h and longer |
| | °C | | |
| Uncoated metal | 51 | 48 | 43 |
| Coated metal | 51 | 48 | 43 |
| Ceramics, glass and stone materials | 56 | 48 | 43 |
| Plastics | 60 | 48 | 43 |
| Wood | 60 | 48 | 43 |

For contact periods lying between the time periods specified in Table 1, it is convenient to interpolate linearly between the burn threshold values set for the next shorter and for the next longer contact period.

NOTE The value of 51 °C for a contact period of 1 min also applies to other materials with high thermal conductivity which are not indicated in Table 1.

**WARNING — The value of 43 °C for all materials for a contact period of 8 h and longer applies only if a minor part of the body (less than 10 % of the entire skin surface of the body) or if a minor part of the head (less than 10 % of the skin surface of the head) touches the hot surface. If the touching area is not only local or if the hot surface is touched by vital areas of the face (e.g. the airways), severe injuries may occur even if the surface temperature does not exceed 43 °C.**

## 5 Assessment of risk of burning

### 5.1 Procedure

In order to assess the risk of burning if the unprotected human skin comes or could come into contact with hot surfaces, the following procedure shall be carried out:

— identification of hot, touchable surfaces;

— task analysis;

— measurement of the surface temperature;

— choice of applicable burn threshold value;

— comparison of the surface temperature and the burn threshold;

— determination of the risk of burning;

— repetition of the assessment.

In Figure C.1, the procedural steps are shown in a flow chart. In 5.2 to 5.8 the steps are specified in detail. An example for the assessment is given in Annex F.

NOTE In specific cases it could be reasonable to deviate from the sequence shown in Figure C.1. For example, the task analysis might be carried out before the identification of all hot touchable surfaces if the number of surfaces to be considered can be reduced by this procedure, or the choice of an applicable burn threshold value might be carried out before measurement of the surface temperature.

### 5.2 Identification of hot, touchable surfaces

The product having a hot surface or several hot surfaces shall be carefully considered. All necessary information concerning the hot surface(s) of the product shall be gathered. This includes the attributes:

— accessibility of the surfaces;

— rough estimation of the surfaces temperatures (hot, moderate, cold);

— materials of which the surfaces consist;

— textures of the surfaces;

— all operating conditions of the product including the worst case, i.e. the case with the highest surface temperatures.

NOTE If more specific information is needed to determine the accessibility of the surface of a product, reference can be made to other appropriate standards such as IEC 61032 and EN 71-1.

## 5.3 Task analysis

All necessary information concerning the use of the product shall be collected. By analysis or observation, describe the activities and tasks involved in using the product. Particular attention shall be paid to possible intentional and unintentional contact with hot surfaces and to the categories of persons (users of the product and others) to which it may occur. The likely nature of the contact (probability and contact period) shall also be identified.

From the task analysis, the following information is obtained:

— surfaces that are, or which may be, touched;

— intentional or unintentional touching;

— duration of contact with surfaces;

— persons who come or who might come into contact with surfaces;

— probability of unintentional touching;

— frequency of intentional touching;

— actual range of power/temperature settings of the product during use.

All steps during the use of the product shall be included, i.e. normal use, maintenance, repair, etc.

## 5.4 Measurements of surface temperatures

### 5.4.1 Procedure

The surface temperature shall be measured on that part or those parts of the product where contact of the skin with the surface can occur.

The measurement shall be carried out under the normal operating conditions of the product. The extreme end of the range of the normal operating conditions shall be included so as to provide maximum surface temperatures.

When measuring the surface temperature, care shall be taken that good contact is established between the sensor and the surface. If necessary, use appropriate force and a conducting paste for this purpose according to ISO 7726. The area of contact should lie flat on the surface and may not become canted. The measured value should not be read until temperature equilibrium between the surface and the sensor has been reached. To reach this equilibrium more quickly, it may be convenient to heat the contact sensor of the measuring instrument at a different point of the hot surface before carrying out the actual measurement.

### 5.4.2 The measuring apparatus

The measurement of the surface temperature shall be carried out by means of an electrical thermometer with a contact sensor made of metal and insignificant heat capacity. The accuracy of the instrument shall be at least ± 1 °C in the range up to 50 °C and at least ± 2 °C in the range above 50 °C.

NOTE The data presented in this part of ISO 13732 have been evaluated using the above-mentioned measuring facility and results obtained by other techniques may not be suitable for comparison with the data.

## 5.5 Choice of applicable burn threshold value

### 5.5.1 Procedure

In order to select the applicable burn threshold value from Clause 4, information concerning the

— contact period,

— surface material, and

— surface texture

shall be extracted from the results of the identification of touchable hot surfaces (5.2) and from the task analysis (5.3). The selection procedure consists of the steps specified in 5.5.2 and 5.5.3.

### 5.5.2 Determination of contact period

#### 5.5.2.1 General

From the results of the task analysis (5.3) it can be deduced

a) whether contact of the skin with a hot surface can occur unintentionally or intentionally, e.g. the touch of control elements, and

b) the category of person who comes or who might come into contact with the hot surface

— healthy adults,

— children,

— elderly people, or

— people with physical disabilities.

#### 5.5.2.2 Unintentional contact

The ability of human beings to react to and terminate unintentional contact with a hot surface after a pain sensation depends on age and physical constitution. The contact period for unintentional contact thus differs from one individual to another.

**a) Healthy adults**

For healthy adults, Table B.1 applies. In general, a minimum contact period of 1 s should be used. A minimum contact period of 0,5 s may be selected when there is absolutely no restriction of movement for the fastest possible withdrawal following a pain sensation from touching a hot surface. If extended reaction time is to be expected (e.g. conditions that restrict ease of movement), a longer contact period should be selected, 4 s is proposed.

**b) Children**

For children, Table B.1 applies. The minimum contact period chosen shall not be less than 1 s. If touching a hot surface and an extended reaction duration due to their age is to be expected, at least 4 s shall be selected.

Until 24 months children do not have reflexes quick enough to enable them to remove their hands from what it is that burns them. They therefore do not always have the ability to get away from hot surfaces. The contact period can be up to 15 s for very young children.

**c) Elderly people**

For elderly people, Table B.1 applies. If the product is used mainly by elderly people, 1 s shall be selected as the minimum contact period. If touching of a hot surface and extended reaction time due to their age is to be expected, at least 4 s shall be selected.

**d) People with physical disabilities**

If people with physical disabilities could come into contact with a hot surface, special consideration shall be given to this contingency, taking into account the nature of the disability and the use of the product. It has to be decided whether Table B.1 is applicable, or if longer contact periods ought to be selected.

#### 5.5.2.3 Intentional contact

If the hot surface is touched intentionally, then, ideally, the maximum duration of contact shall be measured. If the maximum duration cannot be determined by measurement, a representative contact period shall be selected with the aid of Table B.1. This duration shall then be taken as a basis for the actual contact period. For intentional contact with a hot surface no contact period shorter than 4 s shall be used.

In general, Table B.1 applies for healthy adults, children, elderly people and people with physical disabilities. It shall nevertheless be considered whether the product will be used by groups of people other than healthy adults where the task may take longer than the time specified in Table B.1. In that case, the contact periods shall be modified accordingly.

If products are specifically made for people with physical disabilities, then the nature of the disability shall be considered in detail and expert medical advice shall be taken.

### 5.5.3 Selection of the burn threshold

Using the contact period determined according to 5.5.2. and the material and texture of which the surface consists, the burn threshold value shall be taken from 4.2. The result is either a value spread for short contact periods or a certain value for a longer contact period.

Materials not expressly specified in Figures 2, 5, 6 and 7 and Table 1 can in some cases be evaluated according to their heat conductivity properties. The thermal inertia (see Annexes A and D) of the respective material has to be compared with the thermal inertias of the following groups of materials: metals, ceramics and glass materials, plastics or wood. The material can then be accorded a burn threshold value from the material group with the same thermal inertia. The prerequisite for this is that the order of the thermal inertia for the material in question is measured or estimated with sufficient accuracy compared to the thermal inertias of the material groups given in this part of ISO 13732. If the order of thermal inertia of the material in question is not known at all, no burn threshold values can be derived from this part of ISO 13732. This may especially apply to plastics (e.g. expanded polystyrene), where heat conductivity properties can deviate considerably from that of the plastic materials described in 4.2.

## 5.6 Comparison of surface temperature and burn threshold

The surface temperature, measured in accordance with 5.4, shall be compared with the burn threshold value, selected in accordance with 5.5. The following results are possible:

— the surface temperature is above the burn threshold;

— the surface temperature lies inside the burn threshold spreads of Figures 2 to 7 (4.2);

— the surface temperature is below the burn threshold.

## 5.7 Determination of risk of burning

### 5.7.1 Surface temperature above the burn threshold

If the measured surface temperature is above the burn threshold, cutaneous injury upon contact with the hot surface is to be expected, i.e. there is a risk of burning. This risk cannot be quantified, but can be qualified in the following way.

The risk of burning is all the greater:

— the higher the measured surface temperature above the burn threshold;

— the longer the period the surface temperature exceeds the burn threshold;

— the less the risk of burning is known to the person liable to be burned (e.g. children);

— the smaller the chance for counter-reaction;

— the more accessible the hot surface;

— the higher the contact risk in accordance with the intended use;

— the more frequently the contact is likely to occur;

— the smaller can be expected the previous knowledge of the user concerning safe handling of the product.

### 5.7.2 Surface temperature within the burn threshold value spread

If the measured surface temperature lies inside the value spreads of Figures 2 to 7, cutaneous injury may or may not occur. This corresponds to the remaining uncertainty of the burn threshold specification. There is still a certain risk of burning which can be qualified similarly as in 5.7.1.

### 5.7.3 Surface temperature below the burn threshold

If the measured temperature lies below the burn threshold, the skin will not normally suffer injury. There is in general no risk of burning.

NOTE Discomfort or pain can be experienced even if the temperature is lower than the burn threshold. More details on the effect of pain and on protective measures are given in Annexes A, B and E.

## 5.8 Repetition

The assessment of the risk of burning as specified in 5.2 to 5.7 shall be carried out for all hot surfaces of the product which will be or can be touched during use.

The assessment shall be repeated, if

— the construction of the product is changed,

— the range of power/temperature settings of the product changes,

— the use of the product changes, or

— there is a change in any other circumstance which might lead to a different result in the assessment of the risk of burning.

# 6 Protective measures

## 6.1 General

This clause gives guidance about protective measures against burn. Detailed specifications are not within the scope of this part of ISO 13732.

## 6.2 No risk of burning

If the risk assessment according to Clause 5 shows no risk of burning, there is normally no need for protective measures against burn.

## 6.3 Risk of burning

If the risk assessment according to Clause 5 shows a risk of burning, in general there is a need for the application of protective measures in order to avoid burns when the skin comes into contact with the hot surface.

If there is a need for protective measures, the particular measures that should be applied depend on the operational context and cannot be specified in this part of ISO 13732. However, the following guidance is given.

Protective measures against burning are all the more important:

— the higher the measured surface temperature above the burn threshold;

— the longer the surface temperature exceeds the burn threshold;

— the less the risk of burning is known to the person liable to be burned (e.g. children);

— the smaller the chance for counter-reaction;

— the more accessible the hot surface;

— the higher the contact risk in accordance with the intended use;

— the more frequently the contact is likely to occur;

— the smaller can be expected the previous knowledge of the user concerning safe handling of the product.

The above-mentioned points are not exhaustive and each situation shall be judged in context.

Examples for protective measures against burns are given in Annex E. In cases in which engineering protective measures can be applied, these are preferred to personal protective measures.

In each particular case, it has to be decided which protective measures need to be applied. Then, all accompanying circumstances should be considered and the above-mentioned factors also taken into consideration. In standards for specific products, appropriate protective measures should be specified if necessary.

One of several possible protective measures is the reduction of the surface temperature to below the burn threshold. To achieve this, surface temperature limit values can be established at or below the burn threshold in product standards or in regulations. It is then the task of the manufacturer of the product to apply technical solutions in order to comply with the established limit values.

Reduction of surface temperatures and the establishing of temperature limit values is applicable only for those parts of a product which are not deliberately heated as an integral part of the functioning of the product. In cases where surfaces of the product have to be hot and accessible in order that the intended operation of the product can be carried out (e.g. operating surfaces of an electrical hob), other appropriate protective measures have to be applied.

# 7 Guidance for setting surface temperature limit values

## 7.1 Procedure

If surface temperature limit values against burning are to be set in standards or regulations, it is recommended that the following procedure be carried out:

— assessment of the risk of burning;

— decision upon protective measures, including the setting of surface temperature limit values;

— selection of appropriate values;

— setting of surface temperature limit values.

The procedural steps are specified in detail in 7.2 to 7.5. They are illustrated in Figure C.2, in the form of a flow chart. An example is given in Annex G.

## 7.2 Assessment of risk of burning

A distinction can be made between surface temperature limit values that are to be set for an existing product and those for a product which will be produced in the future.

**a) Existing product**

For an existing product, a burn risk assessment according to Clause 5 shall be carried out.

**b) Product to be produced or used in the future**

For a product which does not exist at present, or whose future use is not exactly known, a rough burn risk estimation shall be carried out. The information required by 5.2 and 5.3 shall be gathered as far as possible. Reasonable assumptions shall be made for those aspects of the product and of the product's use which cannot be exactly determined. As far as possible, experiences with similar, already existing, products and their use shall be taken into account.

If necessary, a prototype of the product shall be produced and its use tested. Then, even if it is not possible to carry out all the steps of the burn risk assessment given in 5.4 to 5.8, a rough estimation should give the result if there is a risk of burning.

## 7.3 Decision upon protective measures

If the risk assessment according to 7.2 shows a risk of burning, a decision about the application of protective measures shall be carried out. Guidance is given in Clause 6.

One of several possible protective measures is the reduction of the surface temperature to below the burn threshold. A temperature limit value at or below the burn threshold for a hot surface could be set to achieve this in standards or regulations. If it is decided to set a surface temperature limit value, the procedures specified in 7.4 and 7.5 shall be carried out.

## 7.4 Selection of appropriate values

Using the information collected according to 5.2 and 5.3, the applicable burn threshold values shall be selected according to 5.5.

## 7.5 Setting of surface temperature limit value

### 7.5.1 Contact period between 0,5 s and 1 min

When the procedure given in 7.4 is carried out, a burn threshold spread will be obtained as a result for a contact period of between 0,5 s and 1 min. The spread of values obtained shall be “fine tuned” taking the following factors into account.

**a) People who touch or who may touch the surface**

— For healthy adults, elderly people and people with physical disabilities, a figure in the middle of the spread can be chosen.

— For children, a figure more towards the lower end of the spread should be chosen. For products specifically made for children, the value on the lower end of the spread is recommended.

**b) Texture of the surface**

— The more textured the surface, the more can a figure towards the upper end of the spread be chosen.

— The smoother the surface, the more should a figure towards the lower end of the spread be chosen.

NOTE For very high textured surfaces (e.g. corrugated), the thermal capacity of the surface will become small when compared with that of the human skin and detailed considerations are required.

**c) Probability of touching**

— The higher the probability of touching a hot surface, the more should a figure towards the lower end of the spread be chosen.

— The lower the probability of touching a hot surface, the more can a figure towards the upper end of the spread be chosen.

**d) Consequences of touching**

— The more severe the consequences of touching a hot surface, the more essential that a figure towards the lower end of the spread shall be chosen.

— The less severe the consequences of touching a hot surface, the more a figure towards the upper end of the spread can be chosen.

All these factors shall be taken into account when making the adjustment. The importance of each factor depends on the operational context and shall be assessed accordingly. As a result of this “fine tuning”, a single temperature value can then be chosen as the most appropriate burn threshold value.

It is recommended that the determined value be set as the surface temperature limit value against burning.

NOTE The surface temperature limit value selected protects against burning but might not be sufficient to also protect against pain or discomfort.

### 7.5.2 Contact period of 1 min and longer

For contact periods of 1 min and longer, the burn threshold is not given as a spread but as a single value (see Table 1) and the “fine tuning” is not necessary. So it is recommended the burn threshold value determined in accordance with 7.4 be set as the surface temperature limit value against burning.

NOTE For contact periods of 1 min and longer, the burn thresholds are lower than for shorter periods and reaction time is not essential. A person who touches a hot surface will first feel discomfort and then pain. Normally there is time enough to terminate the contact of the skin with the hot surface and no burning will occur. This applies for adults, for children, for elderly people and for people with physical disabilities. Special considerations are necessary for people who cannot feel pain caused by heat and for people whose ability to move is restricted, e.g. very young children lying on a heated pad.

# Annex A
(informative)

# Scientific background

The burn threshold values specified in 4.2 are based on scientific research carried out by several groups.

Experiments were carried out on the skin of pigs, which is very similar to human skin [8]. Temperature values of the skin's surface which lead to burning of the skin were investigated. The occurrence of skin injury depends on the skin's surface temperature and on the time during which that surface is exposed to a high temperature. As a result of these investigations, two temperature boundaries for the skin's surface were distinguished for each period of high temperature exposure. The lower indicates the boundary between non-injury and the onset of a reversible cutaneous injury. While the upper indicates the boundary between the occurrence of a reversible injury and the occurrence of an irreversible cutaneous injury which cannot heal and which results in complete destruction of the skin (whole thickness burn).

The heat flow from a hot object to the skin when the object is touched by the skin has also been investigated from a theoretical point of view [9], [10]. Formulae were specified for the calculation of the temperature of the skin surface and inside the skin. Using the skin burns threshold values of Reference [8] it was possible in some cases to calculate the surface temperature of the hot object leading to a burn of the skin when it is touched.

An instrument called a *thermesthesiometer* was constructed, able to measure the temperature occurring at the surface of the skin when a hot object is touched [11], [12].

The thermesthesiometer was used to determine the temperature of a hot object's surface leading to a burn when the object is touched by the skin [15], [16]. The temperature of the hot object was varied until the thermesthesiometer indicated that temperature value lying on the lower borderline between non-injury and the onset of a reversible cutaneous injury determined by Reference [8]. Then the temperature of the object's surface was determined by means of a conventional temperature measuring device. Measurements were carried out for object surfaces made of different materials and for different contact periods.

Experiments were carried out on rats and pigs [17]. The experiments determined, for different materials, those temperatures which lead to burns of different depth and severity when the animal's skin comes into contact with the surfaces hot of the hot materials. Although the temperature steps used were quite large, the results show correspondence with those of References [15] and [16].

The objects' surface temperature values for the onset of burning measured according to References [15] and [16] for short contact periods agree for metals to within 2 °C to 3 °C with the values calculated according to [9] and [10]. For materials with lower heat conductivity, there is also an agreement between the measurement and the calculation, but it is not quite as good as for metals. For material with very low heat conductivity, the calculation leads to results which are systematically higher than the measured values. For these materials, the calculation does not seem to lead to valid results.

The burn threshold values specified in this part of ISO 13732 are based upon the measurement results given in References [15] and [16] for short contact periods and by Reference [8] for long contact periods. The burn threshold values, in particular those for short contact periods, are subject to uncertainty. This is because

— the force of touching can vary,

— the skin can be dry or wet (sweating),

— the scientific determination of the burn threshold contains inaccuracies, and

— materials with slightly different thermal inertias have been combined into one group to simplify the use of the this part of ISO 13732.

All of these influences lead to an uncertainty in the exact location of the burn threshold. In order to take this uncertainty into account, the burn threshold values have not been drawn as lines but as spreads in Figures 2, 5, 6 and 7. However, the mentioned influences are considered to be small compared to the influence of the heat conductivity properties of the materials. So the spreads are small compared to the differences for different groups of materials. For long contact periods, the location of the burn threshold is known with more accuracy. In these cases, exact values are specified in this part of ISO 13732.

Because the document deals only with surfaces of solid products, burn threshold values for water have not been specified in the main part of this part of ISO 13732. Nevertheless, if it is considered necessary to use these values, the burn threshold values for the contact of the skin with water should be derived from the lower limit of the burn threshold spread established for bare metals shown in Figure 2 and from the values for uncoated metal given in Table 1.

For materials not expressly specified in the Figures 2, 5, 6 and 7 and in Table 1, burn threshold values can in some cases be derived in accordance with 5.5.3. This is possible if the heat conductivity properties of the material in question are known. The most important quantity is the thermal inertia, i.e. is the product of density, thermal conductivity and specific thermal capacity [10]. The thermal inertia can be derived from tables (e.g. in Annex D) or has to be measured. If the thermal inertia differs considerably from the thermal inertia of the material groups mentioned in 4.2, no burn threshold value can be derived using this part of ISO 13732. In those cases, it is recommendable that a thermesthesiometer and the method described in References [13], [14], [15] and [16] be used to determine the burn threshold value.

This part of ISO 13732 deals only with temperature data for the burn threshold. But in some cases the pain threshold is of interest, too — for example, if the contact of the hot surface with the skin is intended. Values for the pain threshold may then be derived from Reference [18].

# Annex B
(normative)

# Contact periods

For the estimation of the period of contact of the skin with a hot surface the values in Table B.1 apply:

**Table B.1 — Guidance for the selection of contact periods**

| Contact period up to | Examples of touching a hot surface | |
|---|---|---|
| | Unintentional | Intentional |
| 0,5 s | Touching a hot surface and fastest possible withdrawal following pain sensation without restriction of movement | — [a] |
| 1 s | Touching a hot surface and quick withdrawal following pain sensation | — [a] |
| 4 s | Touching a hot surface and extended reaction time | Activation of a switch, pressing a button |
| 10 s | Falling against a hot surface without recovery | Prolonged activation of a switch, slight adjustment of a handwheel, valve, etc. |
| 1 min | | Turning a handwheel, valve, etc. |
| 10 min | | Use of control elements (controls, handles, etc.) |
| 8 h | | Continuous use of control elements (controls, handles, etc.) |

[a] Not applicable.

# Annex C
(informative)

## Flow charts for application of this part of ISO 13732

See Figures C.1 and C.2.

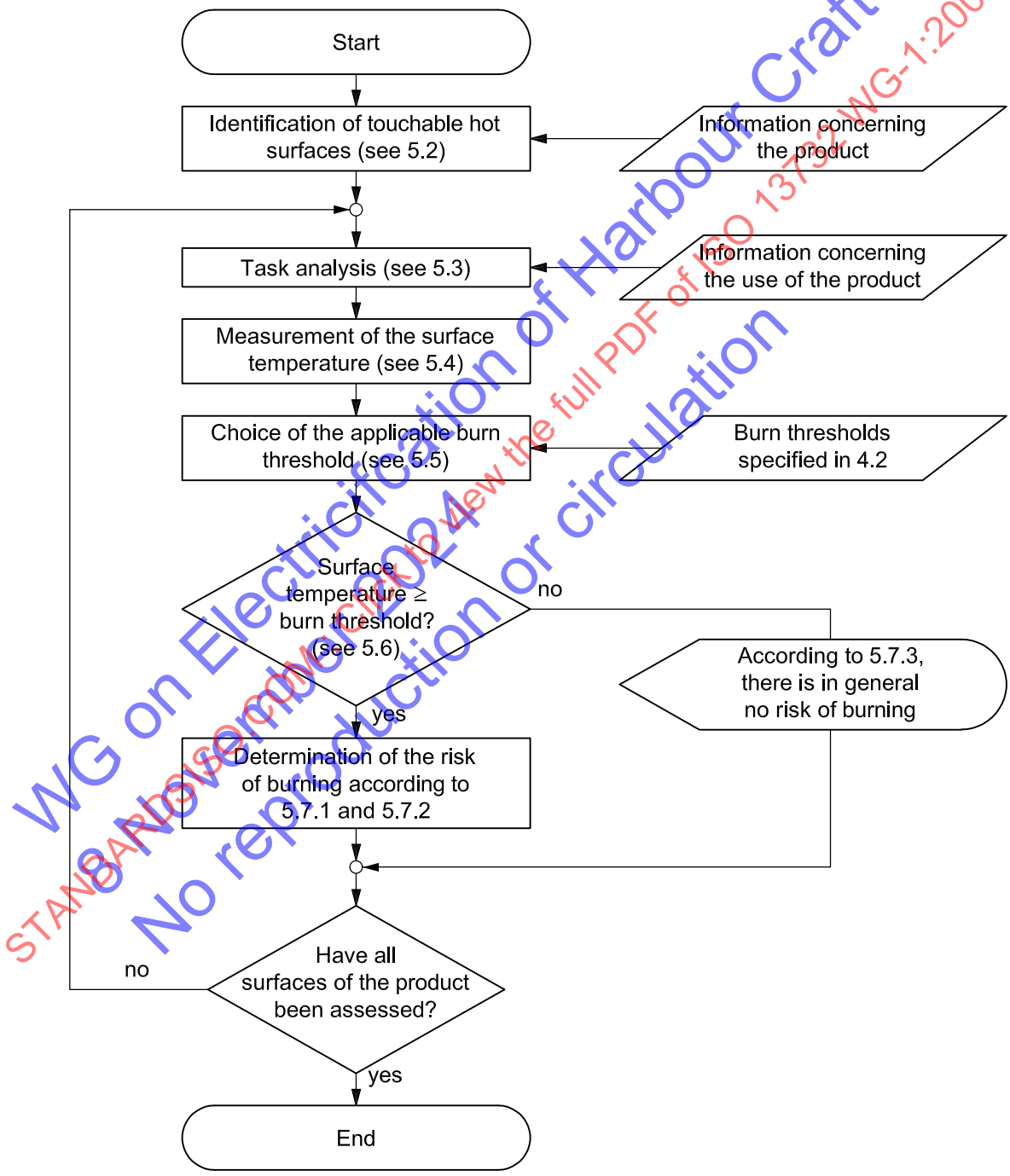



**Figure C.1 — Procedure for assessment of risk of burning**

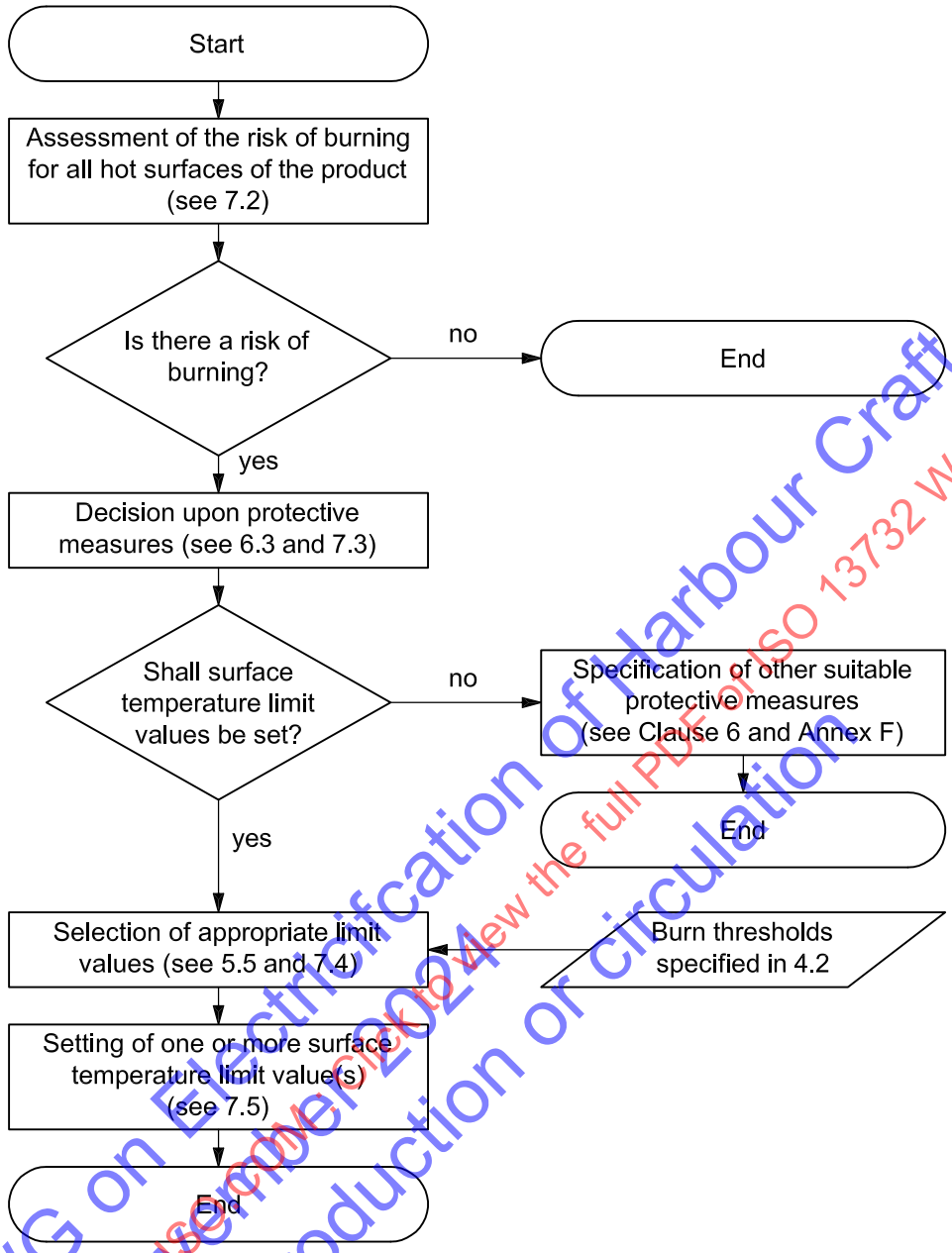



**Figure C.2 — Procedure for setting of surface temperature limit values**

# Annex D
(informative)

# Thermal properties of selected materials

See Table D.1, taken from Reference [9].

**Table D.1**

| Material | Thermal conductivity W/(m·K) | Specific thermal capacity $10^3$·J/(kg·K) | Density $10^3$·kg/m$^3$ | Thermal inertia $10^6$·J$^2$/(s·m$^4$·K$^2$) |
|---|---|---|---|---|
| Skin (avg.) | 0,55 | 4,6 | 0,9 | 2,3 |
| Water | 0,60 | 4,19 | 1,0 | 2,53 |
| Metals | | | | |
| aluminium | 203 | 0,872 | 2,71 | 481 |
| brasses (avg.) | 85,5 | 0,377 | 8,9 | 286 |
| steel | 45,3 | 0,461 | 7,8 | 163 |
| Glass | | | | |
| ordinary glass | 0,88 | 0,670 | 2,6 | 1,51 |
| Pyrex [a] | 1,13 | 0,838 | 2,25 | 2,14 |
| borosodium silicates | 1,22 | 0,838 | 2,2 | 2,25 |
| Stone materials | | | | |
| stone | 0,92 | 0,838 | 2,3 | 1,77 |
| brick | 0,63 | 0,838 | 1,7 | 0,90 |
| marble | 2,30 | 0,880 | 2,7 | 5,48 |
| concrete | 2,43 | 0,922 | 2,47 | 5,51 |
| Plastics (avg.) | 0,25 | 1,55 | 1,28 | 0,49 |
| abs resins | 0,18 | 1,51 | 1,04 | 0,21 |
| fluorocarbons | 0,25 | 0,922 | 2,13 | 0,49 |
| polyamides 6,11, 6,6 | 0,21 | 2,10 | 1,11 | 0,49 |
| acetal | 0,23 | 1,47 | 1,43 | 0,46 |
| cellulose acetate | 0,26 | 1,51 | 1,28 | 0,49 |
| polystyrene GP | 0,12 | 1,43 | 1,05 | 0,18 |
| polyethylenes (avg.) | 0,32 | 2,10 | 0,93 | 0,61 |
| phenolics (avg.) | 0,42 | 1,38 | 1,25 | 0,72 |
| polypropylene | 0,12 | 1,93 | 0,9 | 0,21 |
| Woods (avg.) | 0,18 | 1,72 | 0,66 | 0,233 |
| ash | 0,18 | 1,80 | 0,65 | 0,205 |
| birch | 0,17 | 1,59 | 0,71 | 0,193 |
| oak | 0,19 | 1,72 | 0,70 | 0,230 |
| pine | 0,16 | 1,76 | 0,60 | 0,169 |

[a] Pyrex is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 13732 and does not constitute an endorsement by ISO of this product.

# Annex E
(informative)

# Examples of protective measures against burns

## E.1 Protective measures against burns

Taking into consideration the criteria specified in Clause 6, the following measures can be applied either separately or in combination. Engineering measures are preferred and should be given priority:

a) Engineering measures:

- reduction of the surface temperature;
- selection of surface materials and textures with high burn thresholds;
- insulation (e.g. wood, cork, fibre coating);
- applying guards (screens or barriers);
- surface structuring (e.g. roughening, use of ribs or fins);
- increasing the distance between parts of a product which are intentionally touched and hot surfaces of the product.

b) Organizational measures:

- fixing of warning signs (see Annex H);
- actuating warning signals (visual and acoustic alarm signals);
- instruction and training of users;
- technical documentation, instructions for use;
- setting of surface temperature limit values in product standards and regulations.

c) Personal protective measures:

- use of individual protective equipment (clothing, gloves, etc.).

## E.2 Examples of protective measures

### E.2.1 Protective measures on portable, handheld power tool with combustion engine

A portable handheld power tool with a combustion engine is selected to demonstrate the various requirements for protective measures against the risk of burning. There are three areas of portable power tools for which different protection measures are possible or necessary: the cylinder and muffler, the handles and the transition between.

### E.2.2 Cylinder and muffler

During the combustion process, a considerable amount of heat energy is transmitted to the outer surface of the cylinder and emitted by the cooling air. Simultaneously, the exhaust gases pass through the muffler and heat up the muffler to temperatures far above the burn thresholds for skin contacts with hot surfaces. Measures against potential risks of burning are suitable location of the muffler away from direct access by the operator and/or providing a guard for the cylinder and the muffler which avoids direct contact between the operator and the hot surfaces.

### E.2.3 Handles

Contact with the handles occurs intentionally. Therefore, the surface temperature of the handle should be so low that no burning is caused, even if the handle is in contact with the hand over a longer period. Furthermore, the surface temperature should be below the pain level. For this purpose, technical protection measures are required. Technical measures could include an isolation of the handle of the hot product and the use of materials with high burn threshold values, such as plastics and wood (see 4.2).

### E.2.4 Transition area

The specification of protective measures for the transition area between the handles and the hot cylinder, or muffler, is more complicated than the preceding measures. The upper area of such hot components opposite the handle should be examined with special care. The risk of unintentional contact with this upper area is more likely than contact with the outer surface of the power tool. One protective measure would be to reduce the likelihood of unintentional contact with the upper area of the power tool. This could be accomplished by sufficient distance between the handle and the upper surface of the hot components or by providing a protective guard in order to avoid unintentional contact.

Further measures against the risks of burning might be necessary in the case of higher temperatures of the guard than those given in 4.2. In this case, the guard should be designed such that the thermal conductivity is reduced. This can be achieved by means of special surface characteristics such as structuring, rib or coatings.

# Annex F
(informative)

# Example for assessment of risk of burning

## F.1 Object

A flat iron is used to demonstrate the assessment of the risk of burning according to Clause 5 and the assessment of the need for the application of protective measures according to Clause 6.

On a flat iron three areas with different surface temperatures, different risks of burning and different possibilities of the application of protective measures can be distinguished:

— the soleplate;

— the handle;

— the intermediate area.

Burn risk assessments can be carried out for the surfaces of these three areas separately.

NOTE The following values for measured surface temperatures and materials of construction are only examples to demonstrate the application of this part of ISO 13732. Real figures could deviate from these examples.

## F.2 Soleplate

The soleplate has to be hot in order to operate the flat iron.

In a risk assessment according to Clause 5 the following information is collected.

**a) Product information** (according to 5.2)

| | |
|---|---|
| Assessed surface: | soleplate surface |
| Accessibility: | easily touchable |
| Temperature estimation: | very hot |
| Surface material: | steel |
| Texture of the surface: | smooth |
| Operating conditions: | three selectable power stages |

**b) Task analysis** (according to 5.3)

| | |
|---|---|
| Surface which is or may be touched: | soleplate surface |
| Intentional or unintentional touching: | unintentional |
| Persons who contact or may contact: | adults and children |
| Duration of contact: | 0,5 s for healthy adults, 4 s for children, 15 s for very young children (see 5.5.2) |
| Probability of unintentional touching: | — low during operation<br>— higher during vertical storage of the flat iron<br>— during vertical storage medium to high for people, who are not aware of the risk of burning, like young children |
| Frequency of intentional touching: | zero |
| Actual range of power/temperature settings: | maximum selectable power stage |

**c) Measurement of surface temperature** (according to 5.4)

The maximum measured temperature of the soleplate when the flat iron is operated at maximum power is 250 °C in this example.

**d) Choice of applicable burn threshold** (according to 5.5)

The burn threshold spread for a smooth surface made of steel and a contact period of 0,5 s is 67 °C to 73 °C. These figures apply if only adults have access to the flat iron. If also children have access burn spreads of 58 °C to 63 °C (4 s contact period) respective 55 °C to 59 °C (15 s contact period) apply.

**e) Comparison and conclusion** (according to 5.6)

The measured surface temperature is far above the applicable burn threshold spreads. Cutaneous injury upon contact with the hot soleplate is to be expected. This applies both for contact of adults and for contact of children with the soleplate surface.

**f) Result of risk assessment** (according to 5.7)

The temperature of the soleplate far exceeds the burn thresholds. A risk of burning therefore exists. The probability of contact with the heated soleplate is low when the flat iron is used by experienced adults at home or in the workplace. When inexperienced young children have access to a flat iron in the home the probability of a contact with the heated soleplate is medium-to-high. When the heated soleplate is touched by the unprotected skin severe injuries can be expected to occur. Altogether, the risk of burning is low-to-medium when the flat iron is used by experienced adults. The burning risk is medium-to-high when inexperienced children have access to a heated flat iron.

**g) Application of protective measures** (according to Clause 6)

As the soleplate has to be hot to operate the flat iron, reduction of the soleplate's temperature below the burn threshold in order to eliminate the risk of burning is not possible. Other appropriate protective measures should be applied (see Annex E). Normally, adults are aware of the risk of burning when touching the hot soleplate of a flat iron. Careful use of a flat iron is the common applied protective measure. Measures should be taken to prevent access to a flat iron for inexperienced children. Technical committees preparing product standards could consider including warnings in the instructions for use and signal lights to show the power state of the flat iron.

NOTE Even if the soleplate has to be hot in order to operate and no reduction of the surface temperature below the burn threshold is possible there could be other reasons to limit the soleplate's temperature on a higher level. For example, in order not to destroy the ironed textiles, a temperature limitation may be applied (e.g. to 230 °C). This limitation then serves to prevent against a specific risk but not against the risk of burning.

## F.3 Handle

The temperature of the handle should be so low that there is no risk of burning.

In a risk assessment according to Clause 5 the following information is collected.

**a) Product information** (according to 5.2)

| | |
|---|---|
| Assessed surface: | handle surface |
| accessibility: | easily touchable |
| Temperature estimation: | moderate |
| Surface material: | plastics |
| Texture of the surface: | smooth |
| Operating conditions: | three selectable power stages |

**b) Task analysis** (according to 5.3)

| | |
|---|---|
| Surface which is or may be touched: | handle surface |
| Intentional or unintentional touching: | intentional |
| Persons who contact or may contact: | adults and children |
| Duration of contact: | intermittent touching for several hours |
| Probability of unintentional touching: | not applicable |
| Frequency of intentional touching: | often repeated touching |
| Actual range of power/temperature settings: | maximum selectable power stage |

**c) Measurement of surface temperature** (according to 5.4)

The maximum measured temperature of the handle when the flat iron is operated at maximum power is 60 °C in this example.

**d) Choice of applicable burn threshold** (according to 5.5)

In this example, individual contact durations are assumed to dominate with only short recovery times. Therefore, the continuous 8 h contact period should apply. According to 4.2.3, the burn threshold for a smooth surface made of plastics and a contact period of 8 h is 43 °C.

**e) Comparison and conclusion** (according to 5.6)

The measured surface temperature is above the applicable burn threshold. Cutaneous injury upon contact with the hot surface could occur.

**f) Result of risk assessment** (according to 5.7)

The temperature of the handle exceeds the burn threshold. A risk of burning therefore exists. The burn threshold will be exceeded in this example when the handle is touched for longer than 1 min (see 4.2.3). This means that there is time enough for the user to remove the hand from the handle when he/she feels uncomfortable or pain. Even if the burn threshold is exceeded, the risk of burning is low in this case. But it is not possible to touch the handle continuously during use.

**g) Application of protective measures** (according to Clause 6)

As the handle has to be touched during the use of the flat iron it is necessary to reduce the handle temperature below the burn threshold. Several technical solutions are possible (selection of suitable material, insulation, surface structuring, etc., see Annex E).

NOTE Under practical considerations it may be necessary to lower the handle temperature even below the burn threshold (e.g. to 35 °C or 30 °C) by technical means, so that the user does not feel uncomfortable when using the flat iron continuously.

## F.4 Intermediate area

The intermediate area of the flat iron lies on the back of the soleplate, opposite the handle. It is not necessary to touch the intermediate area but it could be touched unintentionally during the use of the flat iron. (This example does not deal with a selection-wheel for the power stages on the intermediate area.)

In a risk assessment according to Clause 5 the following information is collected:

**a) Product information** (according to 5.2)

| | |
|---|---|
| Assessed surface: | surface of the intermediate area |
| Accessibility: | easily touchable |
| Temperature estimation: | moderate to hot |
| Surface material: | plastics |
| Texture of the surface: | smooth |
| Operating conditions: | three selectable power stages |

**b) Task analysis** (according to 5.3)

| | |
|---|---|
| Surface which is or may be touched | surface of the intermediate area |
| Intentional or unintentional touching: | unintentional |
| Persons who contact or may contact: | adults and children |
| Duration of contact: | 1 s for healthy adults because the movement of the hand could be restricted when the handle is gripped by hand, 4 s for children, 15 s for very young children (see 5.5.2) |
| Probability of unintentional touching: | depending on the distance between handle and intermediate area (e.g. 5 cm), assumed to be high in this example |
| Frequency of intentional touching: | not applicable |
| Actual range of power/temperature setting: | maximum selectable power stage |

**c) Measurement of surface temperature** (according to 5.4)

The maximum measured temperature of the intermediate area when the flat iron is operated at maximum power is 95 °C in this example.