CENELEC GUIDE 29

Temperatures of hot surfaces likely to be touched
Guidance document for Technical Committees and manufacturers

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The present Guide has been developed in response to EC Standardisation Mandate M/346 in the field of the Low Voltage Directive 2006/95/EC addressing surface temperatures of accessible non-functional surfaces.

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Foreword

This Guide was prepared by CENELEC BTTF 120-1, Surface temperatures.

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1 Scope

This document provides guidance for assessing the risk of a burn from unintentional contact with readily accessible surfaces of electrical equipment under the scope of the Low Voltage Directive.

This document establishes surface temperature limits, where such limits are required, and describes the maximum contact periods with a hot surface that a person may be subjected to without being exposed to a risk of burn. Curves of maximum temperatures versus contact times are described for different types of material with different types of surfaces.

This document does not address temperature limits for hot functional surfaces.

This document applies to surfaces of products likely to be touched by any person.

The limit values may be taken into consideration by Technical Committees in determining surface temperature limits in product standards. Manufacturers may also use the limit values to assist in their risk assessment, if a product standard is not applied.

It is not within the scope of this document to set temperature limits for the following zones or surfaces:

- hot functional surfaces;
- adjacent surfaces;
- handles, control knobs including keypads, keyboards and the like;
- surfaces not likely to be touched.

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 13732-1:2006, *Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces – Part 1: Hot surfaces*

EN 61032:1998, *Protection of persons and equipment by enclosures - Probes for verification*

3 Definitions

For the purpose of this guide, the following definitions apply:

3.1
surface temperature (*Ts*)
temperature of a surface, measured in degrees Celsius, at an ambient temperature of 25°C -5°C/+0°C

3.2
contact period (*t*)
time during which contact with the surface occurs

NOTE In Figures A.2 to A.6 contact duration (D) is used to determine the contact period (t)

3.3
thermal inertia
product of the density, thermal conductivity and specific thermal capacity of material

3.4
material properties of the surface
chemical/physical composition of the material and the characteristics (rough, smooth) of the surface

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 a hot surface for a specified contact period

3.6
hot functional surface
surface which is intentionally heated by an internal heat source and which has to be hot to carry out the function for which the equipment is intended to be used. For example, the soleplate of an iron, or curling tongs.

Some equipment have hot surfaces as a consequence of how they generate their output, for example lamps within a luminaire, and are considered in terms of their treatment as equivalent to a hot functional surface

3.7
adjacent surface
a surface adjacent to a functional surface.

The adjacent surface and the functional surface normally consist of the same piece of material or are in direct thermal contact and have similar thermal properties. The adjacent surface is not heated intentionally during use of the product. However, as it is adjacent to the functional surface and may become hot through conduction, its temperature will be in the range between the functional and a touchable surface

3.8
handles or control knobs including keypads, keyboards and the like
part of the equipment that a user needs to touch to operate or adjust the equipment

3.9
touchable surfaces
all other surfaces that are likely to be touched when the equipment is operated during normal use and foreseeable misuse. The equipment has to be installed according to the manufacturer's instructions.

NOTE This means an oven intended for build in should be installed according to the manufacturer's instructions before identification of the touchable surfaces

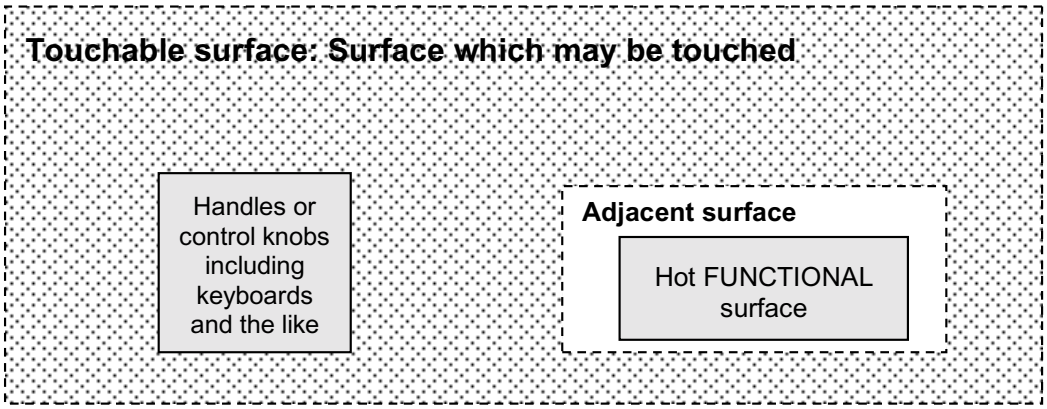

Figure 1 – Definition of the different touchable parts of an equipment

3.10
arms reach
the distance measured from the floor to the fingertips of a person. As shown in Figure 2, it has to be taken into account that a person can reach not only in a vertical direction as shown in Figure 2 (a), but also in a circle defined approximately in Figure 2 (b).

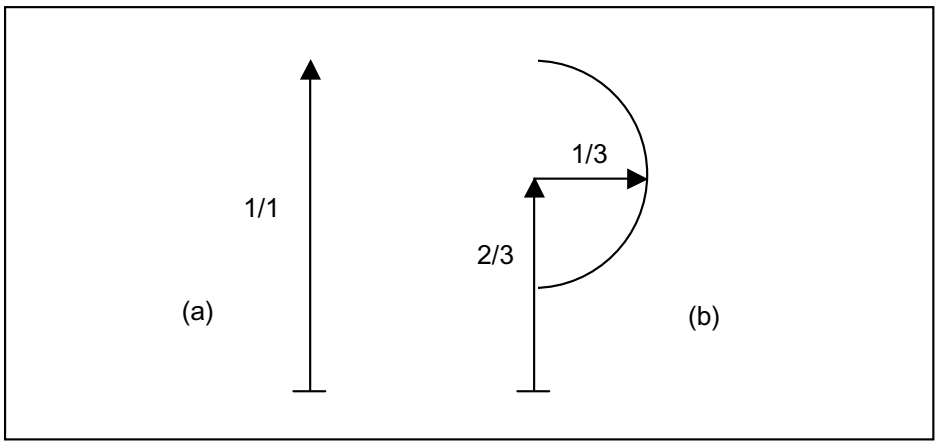

Figure 2 – Arms reach - the distance is interpreted as either a fully stretched person (a) or a person reaching for an item (b). Worst case of either (a) or (b) to be used

Table 1 gives guidance on arms reach for different age groups.

Table 1 – Arms reach

Age years	**Arms reach [see Figure 2(a)], calculated from the floor** metre
Children less than 2 years	1,00
Children from 2 years to less than 6 years	1,50
Children from 6 years to less than 14 years	1,80
Adult	2,30

NOTE The values in Table 1 are average values

3.11
skin temperature (T_C)
temperature at a depth of 80 µm below the surface of the skin, measured in degrees Celsius

4 Assessment of the risk of burning

Normally it is sufficient to follow the product standard. The manufacturer only needs to carry out a risk assessment, if the product standard does not take account of the foreseeable use in relation to the temperatures of surfaces likely to be touched, or if no relevant product standard exists.

4.1 Procedure

The different types of surfaces or zones shall be identified according to 4.2.

To assess the risk of a cutaneous burn from surfaces likely to be touched, the steps described in 4.3 to 4.7 shall be carried out for surfaces identified in 4.2.4.

4.2 Identification of surfaces

All necessary information concerning the surfaces of a product shall be gathered to classify the surfaces according to 4.2.1 to 4.2.4.

4.2.1 Identification of hot functional surfaces

Hot functional surfaces shall be identified when the equipment is installed as for normal use. See 3.6.

4.2.2 Identification of adjacent surfaces

Adjacent surfaces to hot functional surfaces shall be identified. See 3.7.

4.2.3 Identification of handles or control knobs including keypads, keyboards and the like

Relevant parts shall be identified. See 3.8.

4.2.4 Identification of non-functional touchable surfaces

All necessary information concerning the touchable surfaces of the equipment, including the following, shall be gathered:

- accessibility of the surfaces, see 4.2.4.1;
- approximate estimation of surface temperatures (hot, moderate, cold);
- material and texture of the surfaces;
- all normal operating conditions of the equipment including the worst case, i.e the setting which results in maximum temperatures of the surfaces;
- the probability of contact.

4.2.4.1 Touchable surfaces

A surface is considered touchable if parts of the appropriate test probe (EN 61032) can touch the surface. It is the responsibility of the technical committees to decide which test probe shall be used.

If the equipment is installed out of reach it is not considered touchable.

It is up to the manufacturers' risk assessment, based upon the relevant product standard(s), to define the foreseeable use.

NOTE "relevant product standard(s)" means, that the standard(s) covers all risks of the equipment in question.

4.3 Task analysis

All necessary information concerning the use of the product shall be collected. By means of analysis or observation, the activities and tasks involved in using the product shall be described. Attention shall be paid to the means of possible contact with hot surfaces and to which persons (users of the product and others) the contact may happen. From the task analysis the following information is obtained:

- surfaces which may be touched unintentionally,
- users or other persons who will likely touch or may touch the surfaces unintentionally,
- range of operation of the product,
- probability of touching,
- statistical data on relevant incidents, if available,
- maximum setting of the temperature of the product.

4.4 Measurement of the surface temperatures

The surface temperatures shall be measured on touchable surfaces.

The measurement shall be carried out under normal operating conditions of the product that will result in the maximum surface temperature. The chosen operating conditions should reflect the manufacturer's intended use of the product while excluding deliberate misuse or unauthorised modifications of the product or its operating parameters by the user.

If a technical committee has a specified temperature measurement method, that method shall be used. Otherwise 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 in Annex A is based on measurement methods described in EN ISO 13732-1:2006.

4.5 Choice of applicable burn threshold

Based on the identification of the hot surfaces in 4.2, and from the task analysis in 4.3, and by taking account of the surface material and texture, the applicable burn threshold may be chosen using the data in Annex A, if available.

NOTE 1 Annex A provides data and curves for some surface material and texture combinations. Further study may be necessary to determine burn thresholds for materials and/or textures not covered in Annex A.

The contact period to be used for selecting the burn threshold must be according to Clause 6, and must take into consideration the different groups of persons that are likely to come into contact with the surface.

NOTE 2 For products that can be expected to be operated only under supervision or if there is a lower risk of exposure to children and/or people with physical disabilities, applicable contact periods may be reduced.

4.6 Comparison between surface temperature and burn threshold

Compare the measured surface temperatures with the applicable burn thresholds:

- If the surface temperature is above the burn threshold, cutaneous injury upon contact with the hot surface is to be expected.
- If the temperature lies below the burn threshold, the skin will not normally suffer injury.
- If the measured surface temperature lies inside the burn threshold spreads of the figures in Annex A, cutaneous injury may or may not occur. This corresponds to the remaining uncertainty of the burn threshold specification.

NOTE 1 The burn thresholds in EN ISO 13732-1:2006 relate to surface temperatures and not skin temperatures. The relationship between surface temperatures and resultant skin temperatures is discussed in A.1. The occurrence of a burn based on skin temperature is discussed in Annex B.

NOTE 2 In some technical committees (e.g. TC 108), it is under consideration to measure a resultant surface temperature after contact with the body has been established.

4.7 Result of the risk assessment

Based on the analysis in 4.3, the probability of touching a part of the surface of the product which has a temperature higher than the burn threshold shall be determined. As a result, the risk of burning is determined in terms of

- exceeding or falling short of the burn threshold for all parts of the touchable surface of the product,
- probability of contact.

NOTE Hints for the risk assessment are given in Subclause 6.3 of EN ISO 13732-1:2006.

5 Application of protective measures

Protective measures shall be considered according to 5.1 and 5.2. Afterwards the process of risk assessment shall be repeated until the risk level is acceptable.

5.1 Touchable surfaces

If the risk assessment shows that there is a risk of burning it shall be decided whether protective measures are necessary and, if so, which protective measures are appropriate. In order to reduce or to eliminate any risk of burning, protective measures may be applied to products and may also be specified in standards for products which are to be produced in the future.

In general, engineering, organisational or personal protective measures may be applied. Whether it is necessary to apply protective measures at all and which specific measures are appropriate will depend on the context in which a product will be used.

It is outside of the scope of this document to specify protective measures. It is the task of manufacturers and also of standardisation groups to decide upon protective measures appropriate to the intended use of a product. Protective means should be provided together with the equipment.

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

Limitation of surface temperatures and establishment of 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.

5.2 Adjacent surfaces

As the temperature of an adjacent surface may be in excess of the limits of the touchable surfaces, protective measures shall be considered to minimize the risk of burning.

Examples of applicable protective measures in this case include limiting the dimensions to the smallest possible area, use of alternative materials or surface structures to limit the likelihood of touching of adjacent surface, reduction of the temperature flow by de-coupling or insulation from the functional surface.

It is the responsibility of the technical committee or manufacturer to define the size, the temperature limits and any other relevant aspects of this surface, where necessary.

6 Burn thresholds

6.1 Determination of the contact period

6.1.1 General

For the selection of appropriate contact periods, a minimum contact period of 0,5 s – 1 s shall be used. If extended reaction time is to be expected (e.g. for people who need special precautions), a longer contact period of up to 15 s should be selected. See Table 2.

It is essential that when selecting the contact periods, a distinction is made based upon those who may come into contact with the hot surface. See Table 1, Table 2 and 6.1.2:

- adults,
- children,
- elderly people,
- people with physical disabilities.

Table 2 – Contact period

Group	Contact period in seconds
Adults	0,5-1
Children less than 2 years	15
Children from 2 years to less than 6 years	4
Children from 6 years to less than 14 years	2
Elderly people	1-4
Physical disabilities	According to nature of disability

NOTE The exact value for adults shall be chosen based on the nature of the products and where they are intended to be used.

6.1.2 Selection of contact periods

6.1.2.1 Adults

For adults a minimum contact period of 0,5 s - 1 s shall be used.

6.1.2.2 Children

If children may touch the touchable surfaces, an extended reaction time due to their age is to be expected, and at least 4 s shall be selected.

If children aged between 6 and 14 may touch a touchable surface, a contact period of 2 s may be used.

Until 24 months of age, children do not have reflexes fast enough to respond to contact with a hot surface. Thus, the contact period may be up to 15 s for very young children.

6.1.2.3 Elderly people

If elderly people may touch the touchable surface, 1 s shall be selected as the minimum contact period. If an extended reaction time due to their age is to be expected, at least 4 s shall be selected.

NOTE The majority of products covered by the Low Voltage Directive are commonly used by elderly people.

6.1.2.4 People with physical disabilities

Where people with physical disabilities may come in contact with hot surfaces, 1 s shall be selected as the minimum contact period. Special consideration shall be made by the technical committee taking into account the nature of the disabilities and the use of the product.

6.2 Selection of the burn threshold

With the aid of the established contact period, the burn threshold shall be determined from the graphs in the figures in Annex A or from Table A.1.

For contact periods between 10 s and 1 min, an interpolation can be made between the burn threshold value indicated for the specific material in the figures in Annex A for 10 s and the value in Table A.1 corresponding to the contact period of 1 min.

For contact periods longer than 1 min, lying between the time periods specified in Table A.1, it is convenient to interpolate between the burn threshold values set for the next shorter and for the next longer contact period. Figures for thresholds to be adapted for 0,5 s to 15 s (see A.2).

For the purpose of setting temperature limit values, it is recommended to proceed in the following way: inside the spread of burn threshold values for material group in the figures in Annex A it is recommended to choose a temperature value lying nearer the lower end of the spread if the probability of touching the hot surface is high, and to choose a temperature value nearer the higher end of the spread when the probability of touching the surface is less.

Materials not expressly mentioned in the figures in Annex A and Table A.1 can in some cases be evaluated according to their heat conductivity properties. The thermal inertia (see Annex B and Annex C) of the respective material has to be compared to the thermal inertia 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 that is that the order of the thermal inertia for the material in question may be measured or estimated with sufficient accuracy compared to the thermal inertia of the material groups given in this guideline. 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 standard. This may especially apply to plastics (e.g. styropor), where heat conductivity properties may deviate considerably from that of the plastic materials described in Annex A. In case of doubt about specific materials technical committees can use the procedure defined in EN ISO 13732.

When a product in normal use can be touched by children a value towards the lower end of the burn threshold spreads in the figures in Annex A shall be selected for contact periods between 1 s and 10 s. For products specifically for children the values on the lower end of the spreads are recommended. For contact periods between 10 s and 1 min an interpolation shall be made between the lower end in the spread for a contact period of 10 s and the burn threshold for 1 min. For contact periods of 1 min and longer Table A.1 applies also to children.

6.3 Texture of the surface

The texture of the surface will affect the nature of the contact. For rough surfaces, values more towards the upper end of the burn threshold spreads in the figures of Annex A could be taken and for smooth surfaces values more towards the lower end of the spreads could be taken.

7 Documentation

The result of the assessment, data that was used to carry out the risk assessment, measurement values, drawings, data sheets and the like have to be documented.

NOTE Applying a harmonised or other recognised relevant standard is an acceptable means of carrying out a risk assessment (as in Clause 4).

Annex A

Burn thresholds

A.1 General

This annex provides surface temperature data for burn thresholds. An estimate of the risk of burning is possible by measuring the surface temperature and by comparison with the values specified in A.2.

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

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

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 B).

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

For short contact periods the burn thresholds are not drawn as lines in the illustrative Figure A.1 and the detailed Figures A.2 to A.6, but are drawn 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 which include: 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 B). However, these influences are considered to be small 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.

A.2 Burn threshold data

A.2.1 Burn thresholds for a contact period between 1 s and 10 s

A.2.1.1 General

In the case of short contacts (contact periods of 1 s to 10 s), the burn threshold spreads are not set in numbers but are reflected in graphs in dependence upon the contact period. The burn thresholds of materials with similar heat conductivity properties were combined to represent one range.

A.2.1.2 Uncoated metals

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

A.2.1.3 Coated metals

The values for the effect of coating a metal are shown in Figures A.3a and A.3b. The values are presented as temperature rise above the burn threshold for uncoated metal. To obtain a burn threshold for coated metal itself, the value for the temperature rise ΔT_s in Figure A.3a or A.3b and the burn threshold for the uncoated metal T_s in Figure A.2 have to be added.

A.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 A.4.

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.

A.2.1.5 Plastics

The burn threshold spread for plastics (polyamide, acrylglass, polytetrafluorethylene, duroplastic) is indicated in Figure A.5.

NOTE Plastics have very different levels of thermal conductivity, depending on the chemical composition. The burn threshold spread for most solid plastics is indicated in Figure A.5. However, for plastics with heat conductivity properties which differ markedly from those of the materials given in A.2.1.5, burn thresholds as indicated in Figure A.5 cannot be used. For these materials burn thresholds have to be calculated, estimated or measured as indicated in Annex B.

A.2.1.6 Wood

The burn threshold spread for wood is shown in Figure A.6.

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.

A.2.2 Burn thresholds for contact periods of 1 min and longer

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

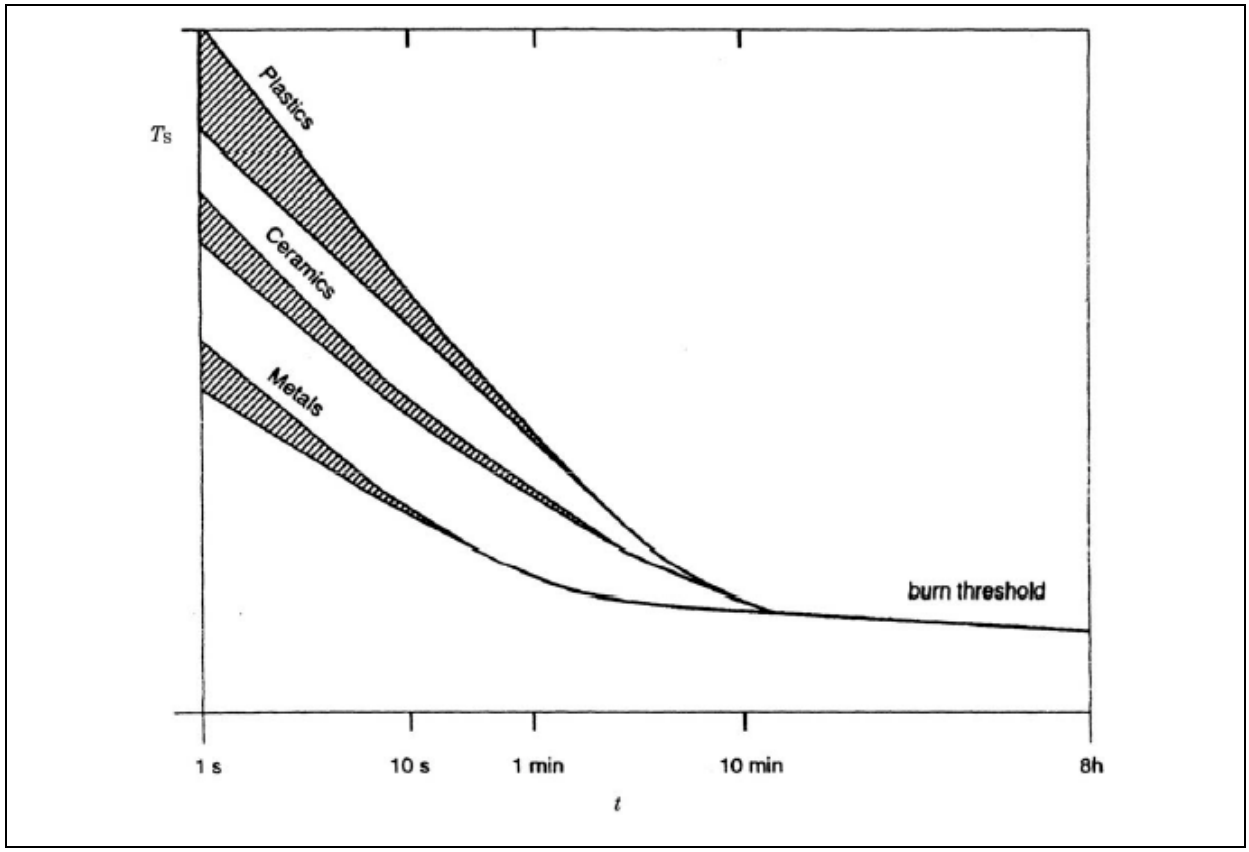

Figure A.1 – Illustration of relationship between the burn threshold and contact period when a hot surface is touched by the skin

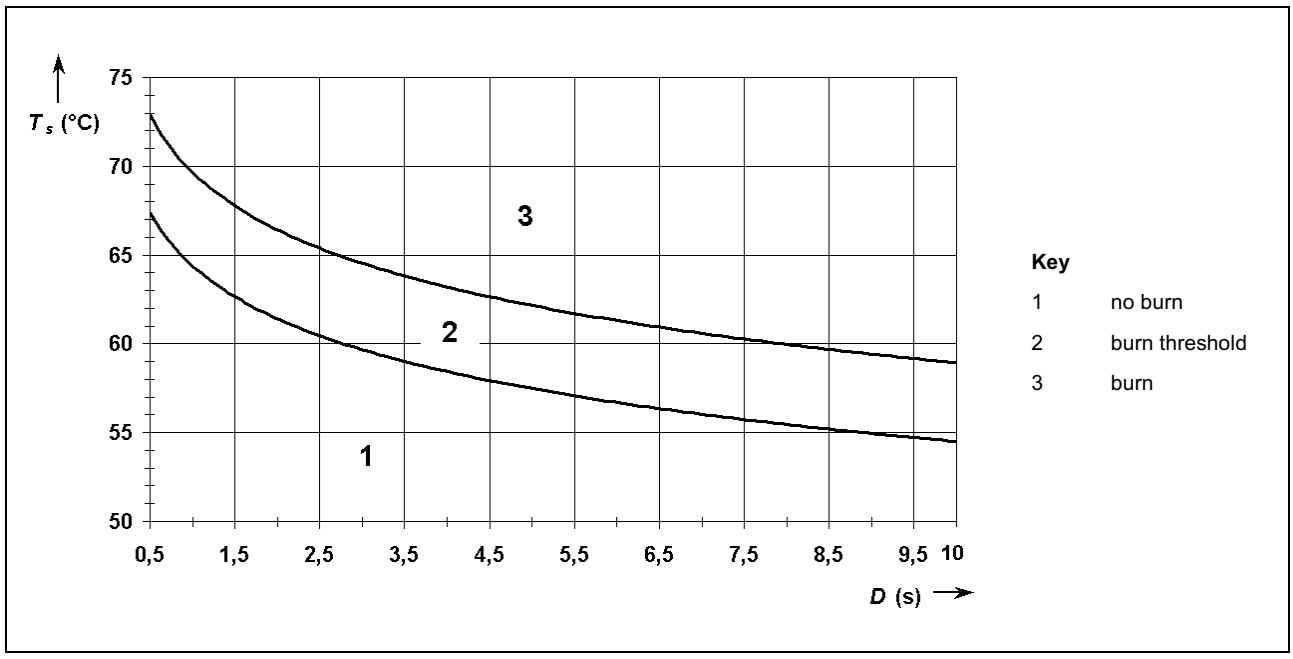

Figure A.2 – Burn threshold spread when the skin is in contact with a hot smooth surface made of bare (uncoated) metal

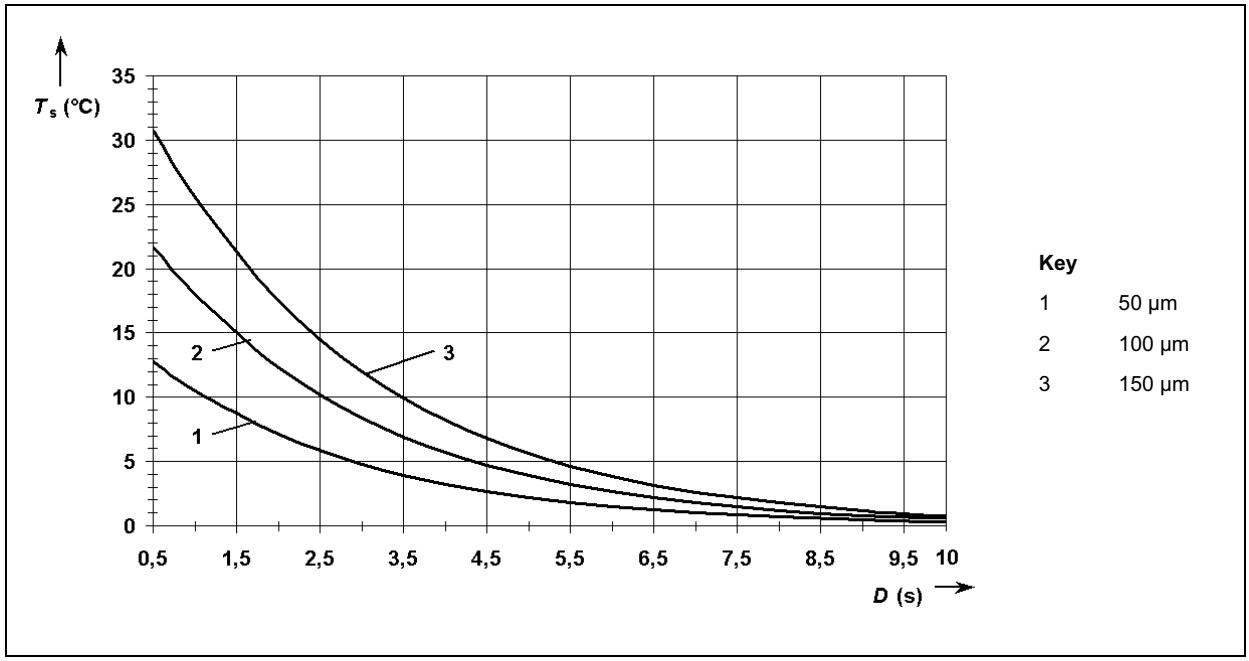

Figure A.3a – Rise in the burn threshold spread from Figure A2 for metals which are coated by lac of a thickness of 50 µm, 100 µm and 150 µm

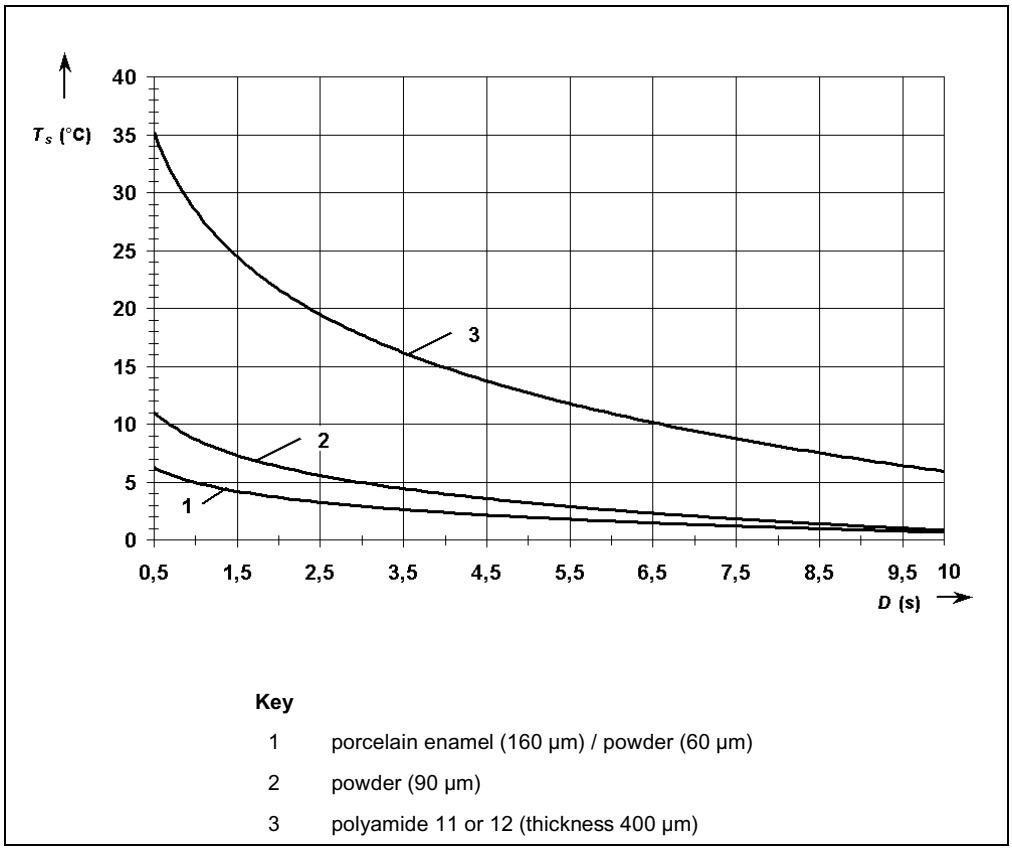

Figure A.3b – Rise in the burn threshold spread from Figure A2 for metals which are coated by porcelain enamel (160 µm) / powder (60 µm), powder (90 µm) and polyamide 11 or 12 (thickness 400 µm)

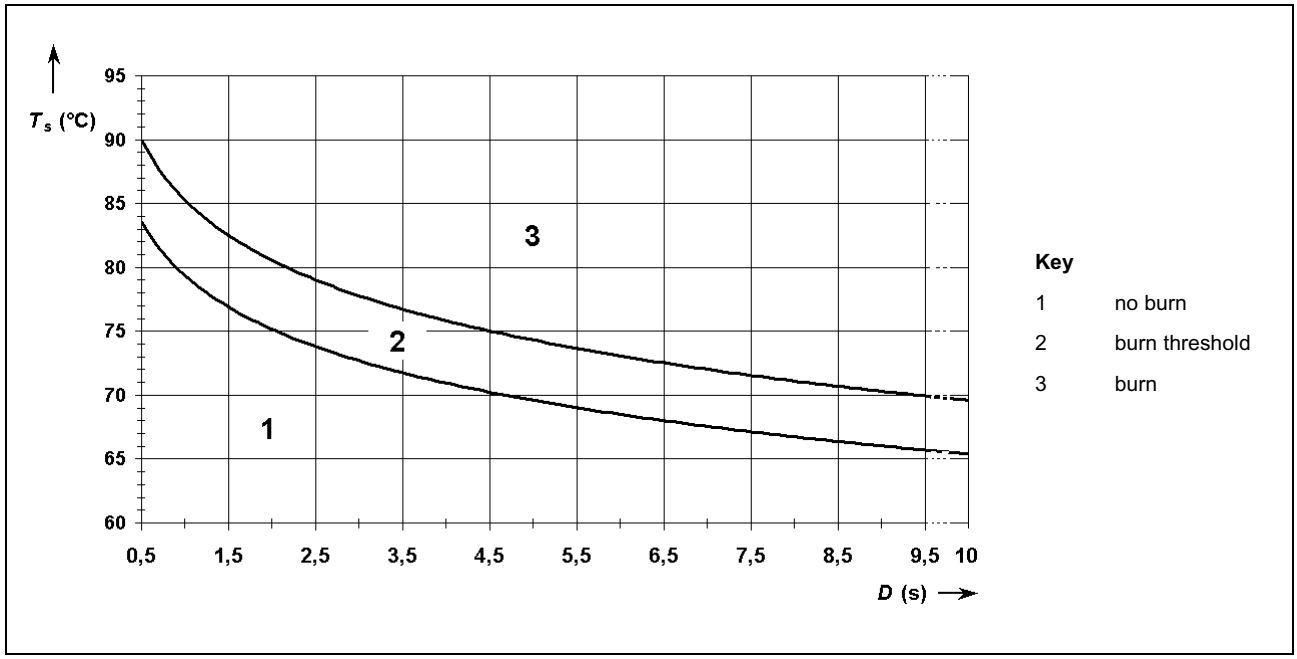

Figure A.4 – Burn threshold spread when the skin is in contact with a hot smooth surface made of ceramics, glass and stone materials

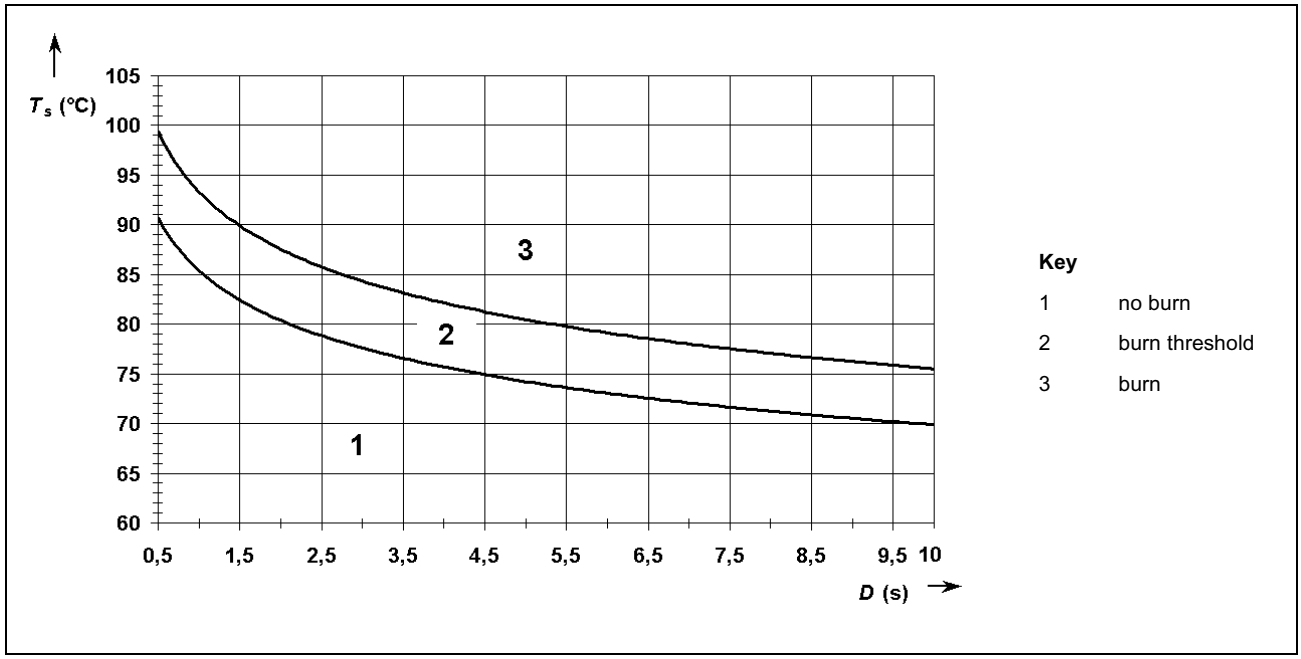

Figure A.5 – Burn threshold spread when the skin is in contact with a hot smooth surface made of plastics

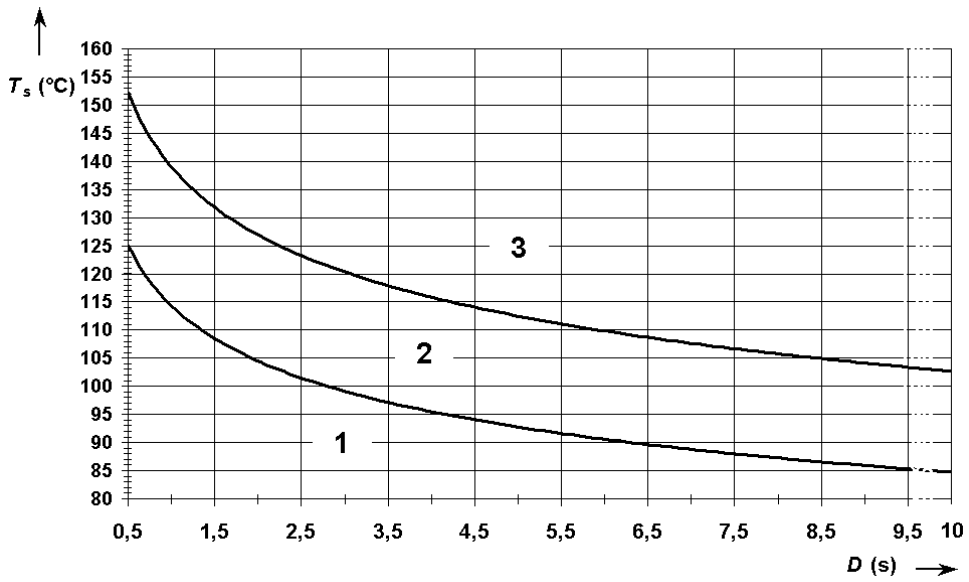

Figure A.6 – Burn threshold spread when the skin is in contact with a hot smooth surface made of wood

Table A.1 – Burn threshold for longer contact times

Material	**Burn threshold T_s for**		
Contact period of	**1 min**	**10 min**	**8 h and longer**
	°C	°C	°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

Interpolation shall be made for contact periods between the values given in the table.

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

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.

Annex B
(informative)

Scientific background

The burn threshold values specified in A.2 are based on scientific research carried out by several groups. Moritz and Henriques carried out experiments with the skin of pigs, which is very similar to human skin [2]. They investigated the temperature values of the skin surface, which lead to a burning of the skin. The occurrence of a skin injury depends on the skin's surface temperature and on the time during which the skin surface is exposed to a high temperature. As a result of the investigations, Moritz and Henriques distinguished for each period of high temperature exposure two temperature boundaries for the skin's surface. The lower indicates the boundary between non-injury and the onset of a reversible cutaneous injury. The upper one indicates the boundary between the occurrence of a reversible injury and the occurrence of an irreversible cutaneous injury which cannot heal and results in complete destruction of the skin (whole thickness burn).

From a theoretical point of view Wu investigated the heat flow from a hot object to the skin when the object is touched by the skin [3, 4]. He specified formulae for the calculation of the temperature of the skin surface and inside the skin. Using Moritz and Henriques' skin burns threshold values it is possible in some cases to calculate the surface temperature of the hot object which leads to a burn of the skin when it is touched.

Marzetta constructed an instrument called 'Thermesthesiometer', which is able to measure the temperature which occurs at the surface of the skin when a hot object is touched [5].

Siekmann used the thermesthesiometer to determine the temperature of a hot object's surface which leads to a burn when the object is touched by the skin [7]. He varied the temperature of the hot object until the thermesthesiometer indicated that temperature value which lies on the lower borderline between non-injury and the onset of a reversible cutaneous injury determined by Moritz and Henriques [2]. Then he measured the temperature of the object's surface by means of a conventional temperature measuring device. He carried out measurements for object surfaces made of different materials and for different contact periods.

Bauer and Manzinger carried out experiments with rats and pigs [8]. They 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 hot materials' surfaces. Although the temperature steps used were quite large, their results show correspondence with Siekmann's results.

The objects's surface temperature values for the onset of burning measured by Siekmann for short contact periods agree for metals to within 2 ºC to 3 ºC with the values calculated by Wu's formula [7]. 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 materials 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 value specified in this standard are based upon the measurement results by Siekmann [7] for short contact periods and by Moritz and Henriques [2] for long contact periods. The burn threshold values, in particular those for short contact periods, are subject to uncertainty. This is due to the fact that

- the force of touching can vary,
- the skin can be dry or wet (sweating),
- the scientific determination of the burn threshold contains inaccuracy,

- materials with slightly different heat conductivity have been combined into one group to simplify the use of the standard EN ISO 13732-1:2006.

All of these influences lead to an uncertainty in the exact location of the burn threshold. To take this uncertainty into account the burn thresholds have not been drawn as lines but as spreads in Figures A.2 to A.6. However, the influences mentioned 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 thresholds are known with more certainty. So in these cases exact values are specified in this guideline.

Because the guideline deals only with surfaces of machinery, burn threshold values for water have not been specified in the main part of the guideline. If it is necessary to use these values nevertheless, 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 in Figure A.2 and from the values for uncoated metal in Table A.1.

For materials not expressly specified in the figures and Table A.1 burn threshold values can in some cases be derived in accordance with 6.2. This is possible if the heat conductivity properties of the material in question are known. The most important quantity is the thermal inertia, that is the product of density, thermal conductivity and specific thermal capacity [4]. The thermal inertia can be derived from tables (e.g. in Annex C) or has to be measured. If the thermal inertia differs considerably from the thermal inertia of the material groups mentioned in 6.2 no burn threshold value can be derived from this guideline. In those cases it is recommended to use a thermesthesiometer and the method described in [6] and [7] to determine the burn threshold value.

This guideline deals only with temperature data for the burn threshold. But in some cases the pain threshold is of interest too, e.g. if the contact of the hot surface with the skin is intended. Values for the pain threshold may then be derived from [9].

Annex C
(informative)

Thermal properties of selected materials

Table C.1 – Thermal properties of selected materials (taken from [3])

Material	Thermal conductivity W/(m*K)	Specific thermal capacity 10^3*J/(kg*K)	Density 10^3*kg/m³	Thermal inertia 10^6*J²/(s*m⁴*K²)
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
Glasses				
glass ordinary	0,88	0,670	2,6	1,51
glass 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	151	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 the standard and does not constitute an endorsement by CEN or CENELEC of this product.

Annex D
(informative)

Examples for protective measures against burns

D.1 Protective measures against burns (general)

Taking into consideration the criteria specified in Clause 4, the following measures can be applied either separately or in combination.

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 of 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.

Organisational measures:

- fixing of warning signs (see Annex H of EN ISO 13732-1)
- actuating of warning signals (visual and acoustic alarm signals);
- instruction and training of users;
- technical documentation, instructions for use;
- setting of surface temperature limit values in standards and regulations.

Personal protective measures:

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

D.2 Example for protective measures

D.2.1 Protective measures on a portable, handheld power tool with combustion engine

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

D.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 is 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.

D.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 contacted 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, wood etc. (see Clause 6 of EN ISO 13732-1:2006).

D.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. The upper area of these hot components opposite the handle should be examined with special care. The risk of unintentional contact with this upper area is higher 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 Clause 6 of EN ISO 13732-1:2006. 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.

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