BRITISH STANDARD

BS EN 563:1994

Incorporating Amendment Nos. 1 and 2 and Corrigendum No. 1

Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces

The European Standard EN 563:1994 including its amendment A1:1999 has the status of a British Standard

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8972	December 1995	Introduction of annex G, national annex NC and alteration to Figure 3b
10797	March 2000	Indicated by a sideline
10961 Corrigendum No. 1	May 2000	Reinstates text missing from amendment No. 2 (AMD 10797)

Contents

National foreword

This British Standard has been prepared under the direction of the Personal Safety Equipment Standards Policy Committee and is the English language version of EN 563:1994, *Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces*, including corrigendum October 1994 and amendment A1:1999 published by the European Committee for Standardization (CEN).

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 24, an inside back cover and a back cover.

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English version

Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces

(includes amendment A1:1999)

Sécurité des machines — Températures des surfaces tangibles — Données ergonomiques pour la fixation de températures limites des surfaces chaudes
(inclut l'amendement A1:1999)

Sicherheit von Maschinen — Temperaturen berührbarer Oberflächen — Ergonomische Daten zur Festlegung von Temperaturgrenzwerten für heisse Oberflächen
(enthält Änderung A1:1999)

This European Standard was approved by CEN on 1994-06-14; amendment A1 was approved by CEN on 1999-07-01. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

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Foreword

This European Standard has been prepared by the Technical Committee CEN/TC 122, Ergonomics, the secretariat of which is held by DIN.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

This is a type B1-standard in a series of standards for machinery safety. This means that it should be used when determining the requirements in type C-standards in a series. In addition, this standard should be used to contribute to the establishment of design and construction specifications when appropriate C-standards do not exist. Although specifically written for the safety of machinery, this type B1-standard can be used for other appropriate fields of application.

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given only for information. In this standard Annex B is normative and Annexes A, C, D, E, F and G are informative,

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 1994, and conflicting national standards shall be withdrawn at the latest by December 1994.

In accordance with the CEN/CENELEC Internal Regulations, following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Foreword to amendment A1

This amendment EN 563:1994/A1:1999 to EN 563:1994 has been prepared by Technical Committee CEN/TC 122, Ergonomics, the Secretariat of which is held by DIN.

This amendment to the European Standard EN 563:1994 shall be given the status of a national standard either by publication of an identical text or by endorsement, at the latest by February 2000, and conflicting national standards shall be withdrawn at the latest by February 2000.

This amendment to the European Standard EN 563:1994 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

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

Contents

0 Introduction

Accessible surfaces of machinery, which are hot when operated, represent sources of risk of burning. Touching such hot surfaces may take place intentionally, e.g. to operate a handle of the machine, or may take place unintentionally, when a person is near the machine. General directions for the design of safe machinery, taking into consideration measures against hazards, including thermal hazards, are specified in EN 292.

To assess the risk of burn due to a hot surface it is necessary to know those factors and influences which lead to a burn when a hot surface is touched by the skin. The most important factors are:

— the temperature of the surface;

— the material of which the surface consists;

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

Other factors may also occur but are of minor importance. In this standard data are specified to assess the risk of burn, when a hot surface is touched by the skin. These data may also be used if it is necessary to set temperature limit values for hot surfaces in other standards or regulations.

The data specified in this standard are based on scientific research and represent, as far as is known, the behaviour of the human skin when in contact with a hot surface.

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 burn threshold curves for longer contact periods. Considering human reaction times and their distribution in the population 0,5 s is the minimum applicable contact period for healthy adults on an acceptable safety level.

1 Scope

This standard establishes ergonomics data and their use in establishing temperature limit values for hot surfaces and in the assessment of the risks of burning.

This standard is applicable within the field of application of the EN 292 to hot surfaces of machinery that are or can be touched during normal use.

This standard provides data concerning circumstances under which contact between bare skin and hot surface does or may lead to burns. These data allow the assessment of risks of burning.

This standard also provides data to be used to establish temperature limit values for hot surfaces to protect against skin burns. These data can be used in the development of standards for specific machinery where as a result of a risk assessment temperature limits are required.

The data of this standard are applicable to surfaces of objects with relatively high thermal capacity compared with that of the skin of the human body.

This standard 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. This standard is also not applicable to skin contact of more than 10 % of the head or contact which could result in burns of vital areas of the face.

NOTE 1 In some cases the results of contact with a hot surface may be more serious for the individual, for example:

a) burns resulting in the restriction of airways;

b) a large burn (more than 10 % of the body surface) may impair the circulation by fluid loss;

c) heating of a large proportion of the head or whole body may lead to unacceptable heat strain even in the absence of burning.

This standard is applicable to the healthy skin of adults.

This standard does not provide data for protection against pain.

NOTE 2 If the burn thresholds specified in this standard are not exceeded, there is normally no risk of burning, when the skin comes in contact with the hot surface, but pain may occur nevertheless. If there is also a need for protection against pain, surface temperature values should be taken from suitable other sources (see annex A).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1:1991, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology.*

EN 292-2:1991, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications.*

prEN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles.*

prEN 1050[1)], *Safety of machinery — Risk assessment.*

[1)] Draft standard prepared by CEN/TC 114/WG 14.

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1
surface temperature (T_S)

the temperature of a surface measured in degrees Celsius

3.2
contact period *(t)*

the time during which contact with the surface takes place

3.3
thermal inertia

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

3.4
material properties of the surface

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

3.5
burn classification

burns are classified into 3 levels depending on severity:

a) *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.

b) *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.

c) *whole thickness burn*. When the full thickness of the skin has been destroyed and there are no surviving epithelial elements.

3.6
burn threshold

the 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

4 Burn thresholds

4.1 General

This clause 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 **4.2**. The burn thresholds specified in **4.2** may also be used for the establishment of surface temperature limit values of machinery for protection against burns.

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 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 machine. Therefore in this standard it is not the temperature values of the skin which are specified but the temperature values of hot surfaces of machinery which, when in contact with the skin, lead to burns (the burn thresholds). The temperature of a surface of a machine 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 1. Figure 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 A).

The illustrative Figure 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 Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6 and Table 1.

For short contact periods the burn thresholds are not drawn as lines in the illustrative Figure 1 and the detailed Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 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 A). 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.

4.2 Burn threshold data

4.2.1 *Burn thresholds for a contact period below 1 s*

For very short contacts burn threshold values are listed for a contact period of 0,5 s in Table 2 and Table 3.

Table 2 contains burn threshold spreads for different materials for a contact period of 0,5 s. The specified spreads are extensions of the shaded areas of Figure 2, Figure 4, Figure 5 and Figure 6.

Table 2 — Burn threshold spreads for a contact period of 0,5 s

Material	Extension of Figure No.	Burn threshold spread for a contact period of 0,5 s [°C]
Bare (uncoated) metal	2	67 to 73
Ceramics, glass and stone	4	84 to 90
Plastics	5	91 to 99
Wood	6	128 to 155

Table 3 contains the rise of the burn threshold spread for coated metals for a contact period of 0,5 s. The specified values are extensions of the lines in Figure 3a and Figure 3b. Absolute values for the burn threshold spreads for coated metals can be obtained by adding the values of Table 3 to the burn threshold spread specified in Table 2 for bare metal.

Table 3 — Rise of burn threshold spread for coated metals for a contact period of 0,5 s

Metals with a coating of	Extension of Figure No.	Rise of burn threshold spread for a contact period of 0,5 s [°C]
50 µm lac	3a)	13
100 µm lac	3a)	22
150 µm lac	3a)	31
400 µm Rilsan	3b)	34
90 µm powder	3b)	11
60 µm powder, 160 µm porcelain enamel	3b)	6

4.2.2 *Burn thresholds for contact periods between 1 s and 10 s*

4.2.2.1 *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.

4.2.2.2 *Uncoated metals*

The burn thresholds presented in Figure 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 °C beyond the upper limit of the indicated burn threshold spread.

4.2.2.3 *Coated metals*

The values for the effect of coating a metal are shown in Figure 3a and Figure 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 ΔTs in Figure 3a or Figure 3b and the burn threshold for the uncoated metal Ts in Figure 2 have to be added.

4.2.2.4 *Ceramics, glass and stone materials*

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

4.2.2.5 *Plastics*

The burn threshold spread for plastics (polyamide, acrylglass, polytetrafluorethylene, duroplastic) is indicated in Figure 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 5. However, for plastics with heat conductivity properties which differ markedly from those of the materials given in **4.2.2.5**, burn thresholds as indicated in Figure 5 cannot be used. For these materials burn thresholds have to be calculated, estimated or measured as indicated in annex A.

4.2.2.6 *Wood*

The burn threshold spread for wood is shown in Figure 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.

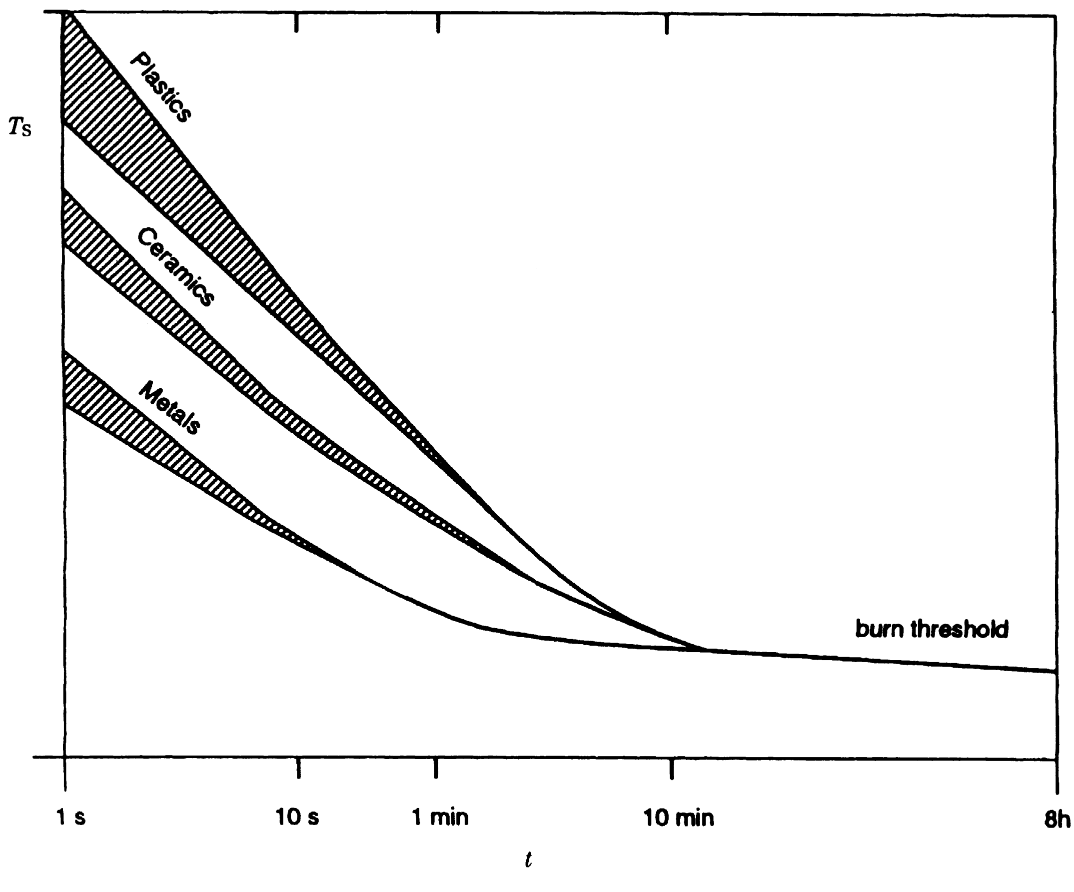


Figure 1 — Illustration of relationship between the burn threshold and the contact period when a hot surface is touched by the skin

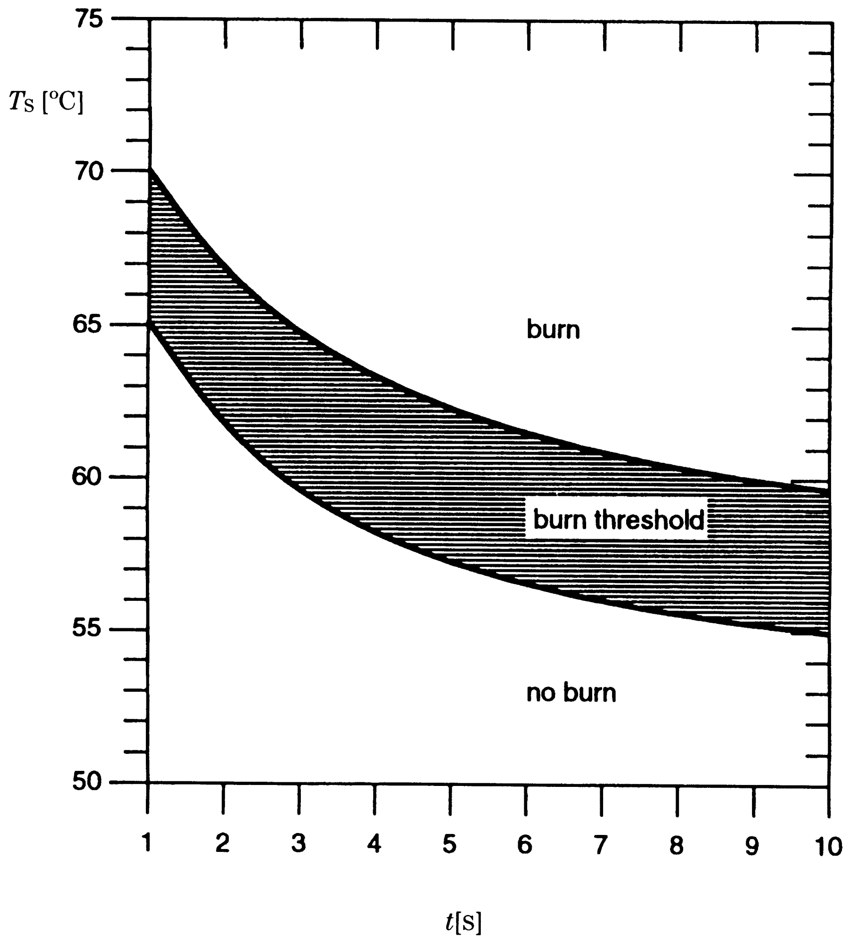


Figure 2 — Burn threshold spread when the skin is in contact with a hot smooth surface made of bare (uncoated) metal

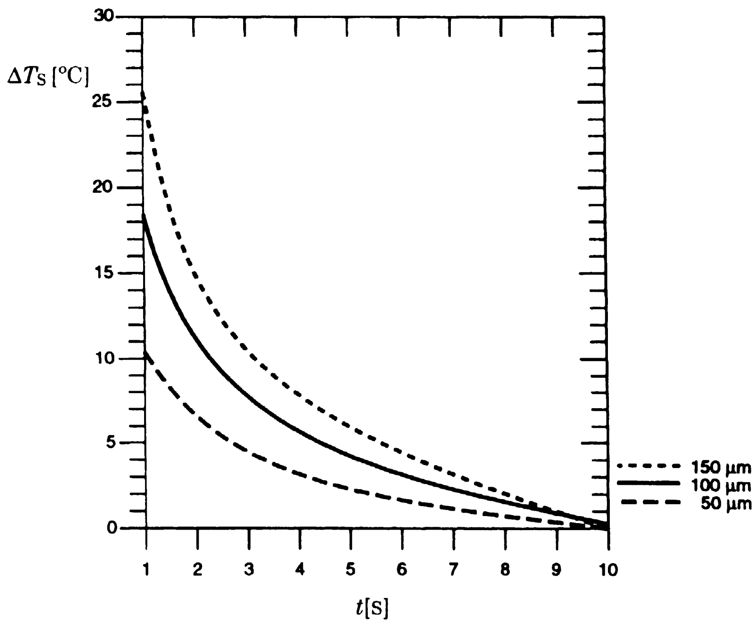
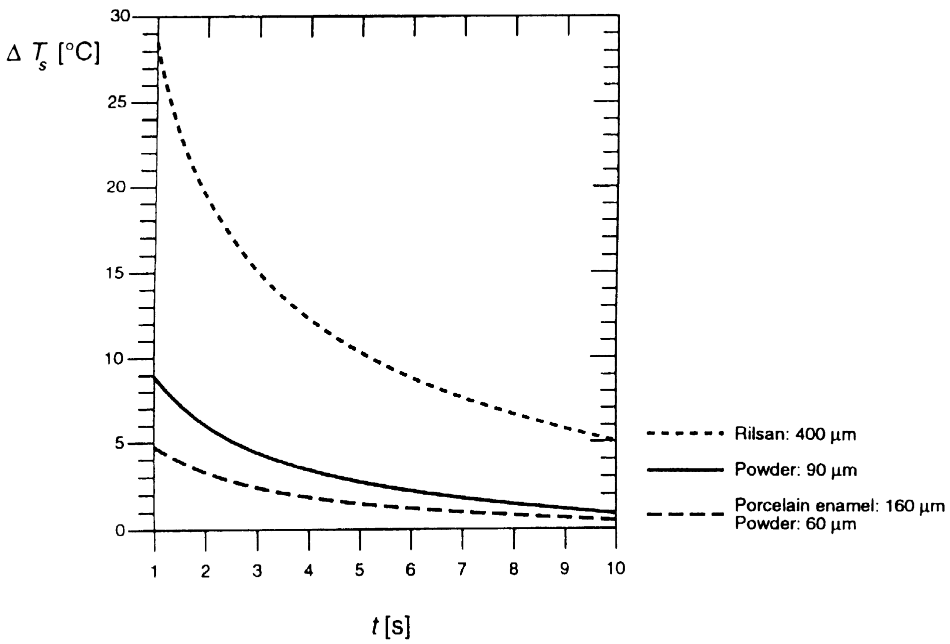


Figure 3a — Rise of the burn threshold spread from Figure 2 for metals which are coated by lac of a thickness of 50 µm, 100 µm and 150 µm



[2] Rilsan is an example of a suitable product available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by CEN of this product.

Figure 3b — Rise of the burn threshold spread from Figure 2 for metals which are coated by Rilsan[2] (thickness 400 µm), powder (60 µm and 90 µm) and porcelain enamel (160 µm)

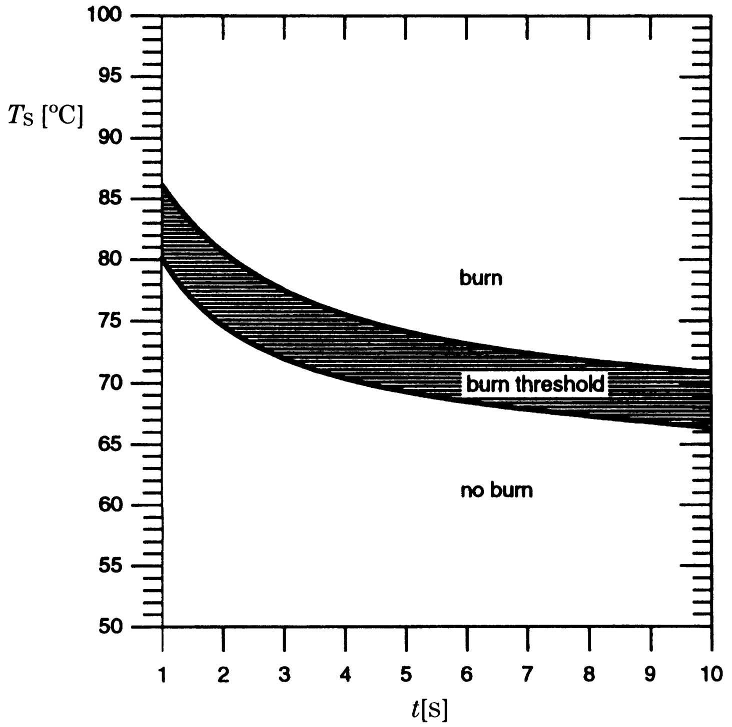


Figure 4 — Burn threshold spread when the skin is in contact with a hot smooth surface made of ceramics, glass and stone materials

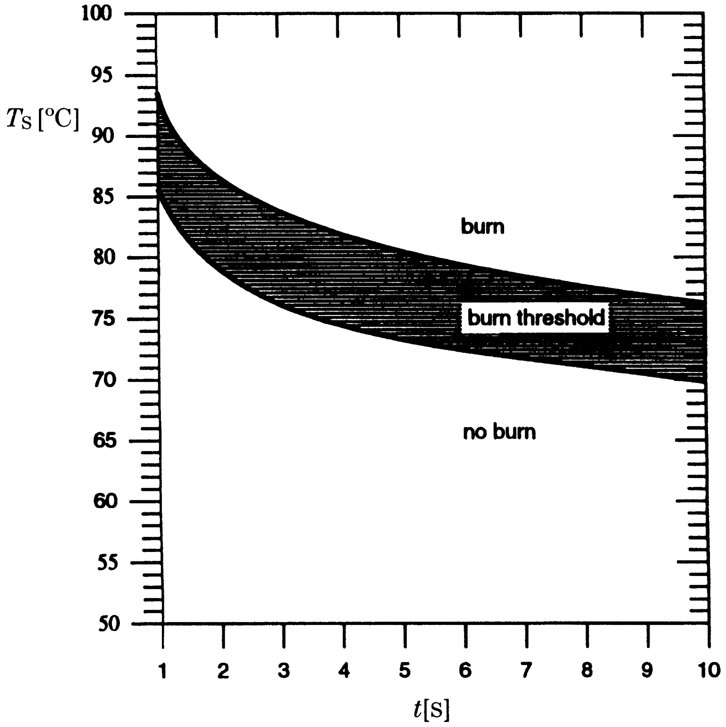


Figure 5 — Burn threshold spread when the skin is in contact with a hot smooth surface made of plastics

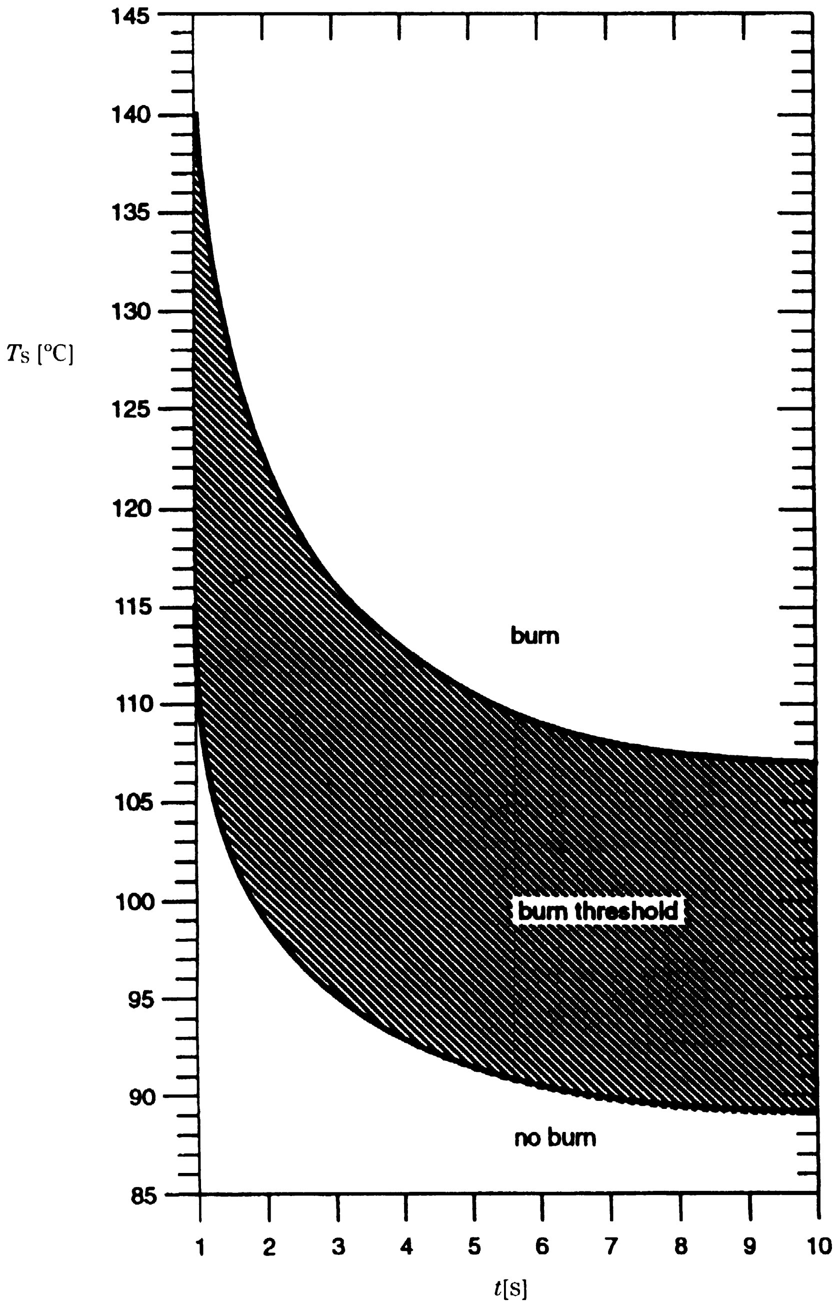


Figure 6 — Burn threshold spread when the skin is in contact with a hot smooth surface made of wood

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

Material contact periods of	Burn thresholds T_s for		
	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

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 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.

5 Application

5.1 General

To assess the risk of burning for the contact of the skin with a hot surface of a machine, the temperature of the surface has to be measured in accordance with **5.2**. Then the value of the burn threshold is derived from this standard. To do this the material properties of the surface and the expected contact period have to be taken into account. The procedure for the proper choice of the burn threshold value is specified in **5.3**. The comparison described in **5.4** of the measured surface temperature and the burn threshold value leads to the decision as to whether there is a risk of burning.

To establish surface temperature limit values for the protection against burns in type C standards these values can be chosen in accordance with **5.3**.

5.2 Measurements

5.2.1 *Procedure*

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

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

NOTE When measuring the surface temperature care should be taken that good contact is established between the sensor and the surface. The use of appropriate force and the use of a conducting paste may be necessary for this purpose. 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 and the indicated value remains constant. 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.

5.2.2 *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 standard have been evaluated using the above mentioned measuring apparatus and results obtained by other techniques may not be suitable for comparison with the data.

5.3 Choice of the burn threshold value to be applied

5.3.1 *General*

For the choice of the applicable burn threshold value the procedure given in **5.3.2** and **5.3.3** shall be carried out.

5.3.2 *Determination of the contact period*

A distinction shall be made as to whether the contact can occur unintentionally or whether it is intended, e.g. to touch control elements.

In the event of non-intended contact, a minimum contact period of 1 s shall be used. Only in the case of a healthy adult and when there is absolutely no restriction of movement a minimum contact period of 0,5 s may be selected. If extended reaction time is to be expected (e.g. conditions that restrict ease of movement, elderly or disabled persons), a longer contact period should be selected, 4 s is proposed. Annex B provides examples for the determination of the contact period in the case of non-intended contact.

If the hot surface is touched intentionally, the maximum duration of contact shall either be measured or be estimated. This time shall then be taken as a basis for the actual contact period. Measurement of the maximum duration shall be given priority. If the maximum duration cannot be determined by measurement, a representative contact period shall be selected with the aid of Table B.1. For an intended contact with a hot surface no contact period shorter than 4 s shall be used.

5.3.3 ***Selection of the burn threshold***

With the aid of the established contact period, the burn threshold shall be taken from the graphs in Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6 or from Table 1, Table 2 or Table 3.

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 Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6 for 10 s (see **4.2.2**) and the value in Table 1 corresponding to the contact period of 1 min (see **4.2.3**).

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

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 one material group in Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6, respective in Table 2, 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 Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6 and Table 1, Table 2 and Table 3 can in some cases be evaluated according to their heat conductivity properties. The thermal inertia (see annex A and annex E) of the respective material has to be compared to 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 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 inertias of the material groups given in this standard. 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[2)]], where heat conductivity properties may deviate considerably from that of the plastic materials described in **4.2**.

5.4 Comparison

If the surface temperature, measured in accordance with **5.2**, is above the burn threshold, selected in accordance with **5.3**, cutaneous injury upon contact with the hot surface is to be expected. If the measured temperature lies below the burn threshold, the skin will not normally suffer injury.

If the measured surface temperature lies inside the spread of Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 6 or Table 2 or Table 3, cutaneous injury may or may not occur. This corresponds to the inherent uncertainty of the burn threshold specification.

6 Interpretation and conclusions

6.1 Surface temperature lower than the burn threshold

If the measured surface temperature is below the burn threshold there is normally no need for protective measures against burning.

NOTE The pain threshold may be exceeded even if the temperature is lower than the burn threshold. Guidance on the pain threshold and on protective measures are mentioned in annexes A and C.

6.2 Surface temperature greater than or equal to the burn threshold

If the measured surface temperature is greater than or equal to the burn threshold, there is a risk of burning the skin when it comes in contact with the hot surface.

2) Styropor 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 of this product.

If there is a need for protective measures, which particular measures should be applied depends on the operational context and cannot be specified in this standard. However the following guidance is given.

Protective measures against burning are all the more important

— the higher the measured surface temperature is 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 is for counter-reaction;

— the more accessible the hot surface is;

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

— the more frequently the contact is likely to occur;

— the smaller the previous knowledge of the user concerning safe handling of a machine with a hot surface is to be expected.

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

In many cases surfaces of machinery have to be hot and accessible to operate (e.g. heated rollers). In such cases reduction to the surface temperature as a protective measure is not practicable. In cases in which engineering protective measures can be applied, these are preferred to personal protective measures. Examples of protective measures are given in annex C.

Which protective measures have to be applied shall be decided in each particular case. Then all accompanying circumstances shall be considered and the above mentioned factors shall also be taken into consideration. In standards for specific machines, appropriate protective measures shall be specified if necessary.

Annex A (informative) Scientific background

The burn threshold values specified in **4.2** 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 °C to 3 °C 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.

All of these influences lead to an uncertainty in the exact location of the burn threshold. To take this uncertainty into account the burn threshold values have not been drawn as lines but as spreads in Figure 2, Figure 3a, Figure 3b, Figure 4, Figure 5 and Figure 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 threshold are known with more certainty. So in these cases exact values are specified in this standard.

Because the standard deals only with surfaces of machinery, burn threshold values for water have not been specified in the main part of the standard. 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 2 and from the values for uncoated metal in Table 1.

For materials not expressly specified in the figures and Table 1 burn threshold values can in some cases be derived in accordance with **5.3.3**. 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 E) or has to be measured. If the thermal inertia differs considerably from the thermal inertias of the material groups mentioned in **5.3.3** no burn threshold value can be derived from this standard. 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 standard 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 B (normative) Examples of contact periods

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

Table B.1

Contact period up to	Examples for touching a hot surface unintentional	Examples for touching a hot surface intentional
0,5 s	touching of a hot surface and fastest possible withdrawal following pain sensation without restriction of movement	—
1 s	touching of a hot surface and quick withdrawal following pain sensation	—
4 s	touching of 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 of a handwheel, valve etc.
10 min		use of control elements (controls, handles etc.)
8 h		continuous use of control elements (controls, handles etc.)
NOTE A contact period of 0,5 s is only applicable if healthy adults can touch a hot surface unintentionally (see **5.3.2**).		

Annex C (informative) Protective measures

C.1 Protective measures against burns

Taking the criteria given in clause **6** into consideration, the following measures can be applied either singly or in combination. Engineering measures are preferred and should be given priority.

a) Engineering measures:
- — reduction of surface temperature;
- — insulation (e.g. wood, cork, fibre coating);
- — guards (screen or barrier);
- — surface structuring (e.g. roughening, use of ribs or fins).

b) Organizational measures:
- — warning signs (warning signals, visual and acoustic alarm signals);
- — instructions, training;
- — technical documentation, instructions for use.

c) Personal protective measures:
- — individual protective equipment.

C.2 Example of protective measures

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.

Cylinder and muffler. During the combustion process a considerable amount of heat energy is transmitted to the outer surface of the cylinder and has to be dispersed 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 surface.

The handles. Contact with the handles occurs intentionally. Therefore, the surface temperature of the handle has to be so low that no burning is caused, even if the handle is contacted over a longer period. Furthermore, the surface temperature has to be below the pain level. For this purpose technical protection measures are required. Technical measures could include an insulation of the handle from the hot machine and the use of material with high burn threshold values, such as plastic, wood etc. (see **4.2**).

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 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, ribs or coatings.

Annex D (informative)
Examples of the application of the standard

D.1 Application to assess existing machinery

D.1.1 *The problem*

Workers have to use a machine in a factory and may come into contact with hot surfaces. It is required to know whether intentional or unintentional contact with the machine will cause burns.

D.1.2 *Method*

D.1.2.1 Establish, by task analysis and observation if possible, worker behaviour under normal and extreme use of the machine. This will allow the identification of touchable surfaces.

D.1.2.2 Establish the normal operating conditions which produce maximum surface temperatures (of parts of the machine which are not deliberately heated as an integral part of the functioning of the machine).

D.1.2.3 If possible discuss, with the operator of the machine, the use of the machine and possible burning.

D.1.2.4 Set the machine to work under the operating conditions described in **D.1.2.2**. Measure surface temperatures of all touchable parts according to **5.2**. While measuring ensure that safety is not compromised.

D.1.2.5 Ascertain measured or estimated contact periods from **D.1.2.1** above.

D.1.3 ***Results***

The temperatures of each touchable part should be assessed separately by comparing measured values with the burn thresholds in **4.2**. For example, suppose the measured temperature of a glass door was 90 °C and it could easily be unintentionally touched. Reference to Figure 4 shows that, even for the minimum considered contact period of 1 s, 90 °C is greater than the upper limit of the burn threshold spread. Skin contact with this surface would therefore be likely to produce a burn.

D.1.4 ***Interpretation***

Although any decision will depend upon context, it is likely that it would be considered unacceptable for the machine to be operated under these circumstances. Possible engineering solutions can be investigated using the data presented in **4.2** and the guidance provided in **6.2** and annex C.

D.2 Application to establish surface temperature limits

D.2.1 ***The problem***

A new machine is to be produced. Temperature limit values are required for surfaces which are not deliberately heated as an integral part of the functioning of the machine (e.g. guards).

D.2.2 ***Method***

D.2.2.1 Identify persons who may touch the surface. Include those who will use the machine (e.g. adults) and those who will not use it but may still come into contact with it (e.g. adults and children in the home or cleaners and on-line maintenance workers at work). Perform an analysis to establish who will come into contact with the surface and the likelihood of contact.

D.2.2.2 Identify materials from which the surface is made (e.g. smooth enamelled metal).

D.2.2.3 From the analysis, estimate the likely and maximum contact periods (e.g. 4 s).

D.2.2.4 Choose the applicable burn thresholds (presented in Figure 2 and Figure 3b in this example).

Figure 2 presents burn threshold values for bare (uncoated) metal. For a contact time of 4 s, these range from 58 °C, below which a burn would not be expected to occur, to 64 °C, above which a burn would be expected to occur. Figure 3b provides the increase in burn threshold, if they are coated with 160 µm enamel. For a contact period of 4 s, this increase is 2 °C. The burn threshold spread in this example is therefore 60 °C to 66 °C.

D.2.3 ***Establishment of a temperature limit value***

The surface temperature limit value will be between 60 °C and 66 °C. The “exact” limit value will be established by consideration of the overall context and discussion between interested parties. For example, the surface temperature limit for a machine which is used in the household may be set at 60 °C, because of the risk of burning of the skin of children or elderly people.

In the case of a machine for trade or industry the limit values may be set higher. It may be reasonable to expect a quicker reaction time and hence a shorter contact period for industrial workers and also to accept a greater risk than that to children. Figure 2 and Figure 3b would give a range of 70 °C to 75 °C for burn thresholds with a contact period of 1 s. In some industrial applications 75 °C may be acceptable when overall risk assessment and other considerations have been taken into account. If surface temperature limits are selected at the upper end of the burn threshold spread, there will be some risk of burning on skin contact.

Annex E (informative) Thermal properties of selected materials

Table E.1 — Thermal properties of selected materials (taken from [3])

Material	Thermal conductivity $\frac{W}{m \cdot K}$	Specific thermal capacity $10^3 \times \frac{J}{kg \cdot K}$	Density $10^3 \times \frac{kg}{m^3}$	Thermal Inertia $10^6 \times \frac{J^2}{s \cdot m^4 \cdot K^2}$
Skin (avg.)	0,545	4,609	0,9	2,28
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	1,28
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
nylons[b] 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 of this product.
[b] Nylon 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 of this product.

Annex F (informative) Bibliography

[1] 89\392\EEC: Council Directive of 14 June 1989 on the approximation of the laws of the Member States relating to machinery, amended by Directive 91\368\EEC.

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[9] British Standards Institution (BSI): *Medical information on human reaction to skin contact with hot surfaces,* PD 6504:1983.

Annex G (informative) A-Deviation

A-Deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

Clause	Country
6.1, Annex A and Annex C	Austria Allgemeine Maschinen- und Geräte-Sicherheitsverordnung (AMGSV), Bundesgesetzblatt Nr. 219/1983, § 10 (2): “Maschinen– und Geräteteile, deren Oberfläche eine höhere Temperature als 60 °C erreichen kann, und die sich innerhalb des auf den Menschen bezogenen Sicherheitsabstandes befinden, müssen, soweit dies bei bestimmungsgemäßer Verwendung möglich ist, gegen Berühren gesichert oder isolierend verkleidet sein. Schutzvorrichtungen müssen aus genügend widerstandsfähigem Material gefertigt und sicher befestigt sein.” Allgemeine Arbeitnehmerschutzverordnung (AAV) § 43 (5): “Rohrleitungen und Armaturen, deren Oberfläche eine höhere Temperatur als 60 °C oder eine niedrigere Temperatur als – 20 °C erreichen kann, und die sich innerhalb des auf den Menschen bezogenen Sicherheitsabstandes nach § 32 befinden, müssen gegen Berühren gesichert oder isolierend verkleidet sein.”

National annex NA (informative) Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Personal Safety Equipment Standards Policy Committee (PSM/-) to Technical Committee PSM/39 upon which the following bodies were represented:

British Airways
British Industrial Truck Association
British Occupational Hygiene Society
British Retail Consortium
British Telecommunications plc
Chartered Institution of Building Services Engineers
Chemical Industries Association
Consumer Policy Committee of BSI
EEA (the Association of Electronics, Telecommunciations and Business Equipment Industries)
Engineering Employers' Federation
Ergonomics Society
Furniture Industry Research Association
Health and Safety Executive
Ice (Ergonomics)
Institute of Occupational Medicine
Loughborough University of Technology
Ministry of Defence
Society of Motor Manufacturers and Traders Limited
Society of Occupational Medicine
Sound and Communications Industries Federation

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Gas plc
British Textile Technology Group
Institution of Fire Engineers

National annex NB (informative) Cross-references

Publication referred to	Corresponding British Standard
	BS EN 292 *Safety of machinery — Basic concepts, general principles for design*
EN 292-1:1991	Part 1:1991 *Basic terminology, methodology*
EN 292-2:1991	Part 2:1991 *Technical principles and specifications*

National annex NC (informative) English translation of annex G

Austria

Allgemeine Maschinen – und Geräte-Sicherseitsverordnung (AMGSV) (General Regulation on the Safety of Machinery and Equipment), Federal Law Gazette No. 219/1983, clause **10**(2):

"Parts of machinery and equipment whose surface can reach a temperature greater than 60 °C and is located within the safety distance for a person shall, where possible when used in accordance with the requirements, be protected to prevent contact or be insulated. Safety devices shall be made of adequately resistant material and shall be securely fastened."

Allgemeine Arbeitnehmerschutzverordung (AAV) (General Regulation on Safety at Work) 43 (5):

"Pipes and fittings whose surface can reach a temperature greater than 60 °C or less than – 20 °C and is located within the safety distance for a person in accordance with clause **32** shall be protected to prevent contact or be insulated."

Annex ZA (informative)
Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and European Free Trade Association and supports essential requirements of EU Directive 98/37/EEC.

WARNING. Other requirements and EU Directives may be applicable to the products falling within the scope of this European Standard

The clauses of this European Standard are likely to support requirements of Directive 98/37/EEC, Annex I.

EU Directive 98/37	Clauses of this European Standard
Annex I, 1.5.5 Extreme temperatures	Clauses **4** to **6** and Annex B

Compliance with this European Standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

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