

TECHNICAL SPECIFICATION



Industrial electroheating and electromagnetic processing equipment –
Requirements on touch currents, voltages and electric fields from 1 kHz
to 6 MHz

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	9
4 Organization and use of this document.....	11
5 Prospective source voltage limits.....	12
6 Assessment of the source impedance.....	12
7 Touching and access considerations	13
7.1 General.....	13
7.2 Primary contact areas	13
7.3 Special protective gloves, footwear and clothing	13
7.4 External metallic objects and tools	14
7.5 Considerations for the secondary contact area assessment	14
8 Impedances of parts of the body, and touch current densities.....	14
8.1 General.....	14
8.2 The equivalent circuit of skin and parts of the body.....	15
8.3 Touch current consideration for large contact areas.....	16
9 Capacitively coupled currents in the body due to an external electric field or insulated live part	16
9.1 General and measurement frequency.....	16
9.2 Determination of the capacitance.....	16
9.3 Assessment of the electric field and use of reference level data.....	17
9.4 Measurement methods and limiting values.....	17
9.4.1 Simplified measurement of the prospective current in the parts of the body	17
9.4.2 More accurate method for determination of currents in the parts of the body	17
9.4.3 Limiting touch current values	17
10 Electric shock – immediate nerve and muscle reactions.....	17
10.1 General.....	17
10.2 Touch current limits – immediate nerve and muscle reactions.....	17
11 Electric shock – local overheating and burns of parts of the body	18
11.1 General and initial thermal conditions	18
11.2 Awareness, perception and withdrawal	19
11.2.2 Heat sensing nerves exist only in the skin region, and thus not in the interior of for example fingers. Conditions where such interior heating occurs while the skin sensing is insufficient for perception are dealt with in 11.3.	19
11.2.3 The perception conditions for hazard calculations are skin temperature rises of at least 3 K over 5 s to 10 s and 5 K over 20 s or less. These times then include the time for withdrawal. The high alternative value 10 s applies if the touching part of the body is large and less easy to withdraw (i.e. the upper arm, leg or torso) than a hand or finger for which 5 s applies.	19
11.3 Long-term tissue overheating.....	19
12 Requirements and risk group classification.....	20
12.1 General.....	20

12.2	Conditions for the touch current limits up to 100 kHz	20
12.3	Requirements related to skin temperature rises and times of awareness, perception and withdrawal	21
12.3.1	Skin heat capacity considerations	21
12.3.2	Skin temperature considerations	21
12.4	Risk level categorisation as function of the prospective contact voltage	22
12.5	Additional protection: residual current protective devices (RCDs).....	22
13	Non-sinusoidal touch currents	22
14	Warning marking and risk group classifications.....	23
Annex A	(informative) Examples of calculations	24
A.1	General.....	24
A.2	Skin heating.....	24
A.3	Examples of tissue heating conditions.....	29
A.3.1	With 1 500 mm ² fingerskin area, i.e. gripping	29
A.3.2	With the maximal fingerskin area 230 mm ²	29
Annex B	(informative) Rationales, references and volunteer studies in the non-thermal case.....	31
B.1	Background and observations	31
B.2	Discussion of Figure B.1	31
B.3	A volunteer study at 11 kHz sinusoidal conditions	33
B.3.1	Experimental setup and data	33
B.3.2	Discussion and analysis of the experimental data	33
B.4	Contact/touch current data from standards and other published documents	34
B.5	Reference levels for the external electric field.....	35
B.6	Prospective touch voltage limits.....	35
B.7	Perception and pain in relation to risk levels.....	35
B.8	Remarks on the slope of the curves for frequencies higher than 10 kHz.....	36
B.9	Remarks on the touch current levels above 100 kHz in ICNIRP and IEEE specifications.....	36
Annex C	(informative) Additional information and rationales – skin data and impedances of parts of the body	37
C.1	Skin anatomy.....	37
C.2	Comparative calculation procedure for wet skin impedances.....	38
C.3	Some data for dry skin	38
C.4	Frequency dependence of the body tissue electrical conductivities	39
C.5	Calculations for Table 1	39
Bibliography	41
Figure 1	– Complex impedances of various parts of the body, 1 kHz to 6 MHz.....	15
Figure 2	– Maximum allowed touch and touch currents, 1 kHz to 100 kHz, immediate nerve and muscle electric shock	18
Figure 3	– Warning markings	23
Figure B.1	– Maximum allowed touch and touch currents in various standards, 1 kHz to 100 kHz, immediate nerve and muscle electric shock.....	32
Figure B.2	– Setup for touch current and voltage measurements with index and middle fingers on 50 mm ² flat conductors	33
Figure B.3	– Current measuring circuit for unweighed touch current, from IEC 60990:2016.....	35
Figure C.1	– Human skin anatomy (from Wikipedia).....	37

Figure C.2 – Average electrical conductivities for homogeneous body modelling from 10 Hz to 10 MHz (from EN 50444:2008)..... 39

Table 1 – Maximally allowed skin power density per surface area, under various conditions of withdrawal..... 22

Table A.1 – Comparison of impedances of parts of the body, using the equivalent circuits in IEC 60990:2016 and in this document 25

Table A.2 – Moist skin, finger and overall heating rate at 50 V overall effective voltage, using equivalent circuits in IEC 60990:2016 and this document 25

Table A.3 – Wet skin, finger and overall heating rate at 50 V overall effective voltage, using this document, with halved skin impedances compared with Table A.2 26

Table A.4 – Effective contact voltage limits for the moist skin examples in Table A.2 27

Table A.5 – Effective contact voltage limits for the wet skin examples in Table A.3 28

Table C.1 – Comparison of complex impedances of moist and wet fingers 39

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL ELECTROHEATING AND ELECTROMAGNETIC PROCESSING
EQUIPMENT – REQUIREMENTS ON TOUCH CURRENTS, VOLTAGES
AND ELECTRIC FIELDS FROM 1 kHz TO 6 MHz**

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62996, which is a technical specification, has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing.

The text of this document is based on the following documents:

Draft TS	Report on voting
27/1005/DTS	27/1010/RVDTS

Full information on the voting for the approval of this document can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this document, the following print types are used:

- terms defined in Clause 3: in bold type.
- in Table A.4 and Table A.5, the resulting voltage limits are bolded, for clarity.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Touch and touch currents and voltages constitute a very important category of electrical safety issues particularly for electroheating (EH) equipment and equipment for electro-magnetic processing of materials (EPM). The equipment manufacturer is mandated to adequately reduce any hazard from touching live equipment parts. For being able to do so, assessments and verifications are necessary for determination of hazards.

During the drafting of IEC 60519-1:2015, it became apparent that there was a need for a technical specification providing an overview, a guidance and requirements for users of that standard, and dealing with the nearest higher frequency interval above that of IEC 61140 and IEC 60204 (all parts). A revised IEC 61140:2016 covers issues up to 1 kHz (up to 200 Hz in earlier editions). Thus, this document deals with touch and touch currents and voltages in the frequency range from 1 kHz to 6 MHz. This range was adopted due to deviating frequency dependence of skin impedances below 1 kHz.

In principle, cases with strong external electric fields where the person is not touching the live insulated or bare live conductor are closely related to cases where the person is actually touching an insulated live conductor. These cases of currents in parts of the body by capacitive coupling are therefore included in this document.

NOTE A parallel IEC technical specification IEC TS 62997:2017 is developed by TC 27, dealing with the magnetic nearfields from 1 Hz to 6 MHz.

The upper frequency limit 6 MHz is chosen due to

- higher frequencies not being expected in internal frequency converters for DC voltage transformation in equipment,
- the free space wavelength of 6 MHz being 50 m, which results in wave phenomena that essentially not exist with or at objects with less than 10 % spatial dimensions of this,
- the fact that the power penetration depth limitation by the equivalent complex permittivity of body tissues has not yet set in at 6 MHz, so currents can be considered to be the same across the two touch areas and their patterns are as with low frequencies, and
- industrial processing frequencies below this limit are typically low impedance; higher impedance dielectric heating has its lowest ISM frequency at 6,8 MHz and is dealt with in IEC 60519-9.

Separation of electric shock (by a current between two parts of the body, creating an internal electric field by the tissue impedance) and induced electric shock (by an internally induced electric field caused by an external alternating magnetic field) is generally possible in the frequency interval considered in this document, since the latter requires a very high current in the conductor generating the magnetic field and conductor resistive losses are low by design. However, touching of such a conductor can occur and both mechanisms will then have to be assessed.

Impedance considerations for skin and other parts of the body are usually not included in sufficient detail in most existing standards, technical specifications and guidelines. With the exception of IEC 60601 (all parts) for medical equipment, no IEC standards provide reasonably complete touch current and voltage specifications. Equivalent test circuits tend to be too general and in some instances even contradictory to established literature data. This specification includes references to relevant IEC, IEEE, ICNIRP, EN and scientific literature data. Additional inputs are from numerical calculations with model situations, and volunteer studies.

Local overheating of particularly skin regions can be the dominating hazard at frequencies higher than some tens of kilohertz. Hazard limits are then to be based on skin impedances, thermal properties and touch as well as current path cross section area considerations. In addition, awareness, perception and withdrawal considerations become crucial. All these factors are dealt with in this document, in a more detailed way than in any other IEC publication.

Even if the scope of IEC TC 27 is limited to industrial electroheating and electromagnetic processing of materials, this document can fill an important gap, with its generally applicable and detailed specifications for higher frequencies than alternating current. It is therefore expected to be of more general use. It should, however, be observed that in particular skin impedances behave non-linearly for frequencies below about 1 kHz.

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INDUSTRIAL ELECTROHEATING AND ELECTROMAGNETIC PROCESSING EQUIPMENT – REQUIREMENTS ON TOUCH CURRENTS, VOLTAGES AND ELECTRIC FIELDS FROM 1 kHz TO 6 MHz

1 Scope

This document addresses the safety assessments in the frequency range between 1 kHz and 6 MHz and provides limits for touch and touch currents for industrial installations or equipment for electroheating (EH) and electromagnetic processing of materials (EPM). Indirect contact by capacitive currents to parts of an earthed human body in an open space are also included, since the current is then distributed analogously in the part of the body and differs from cases of induced electric shock.

NOTE 1 Induced electric shock phenomena are caused by the alternating magnetic field external to a current-carrying conductor, inducing an electric field in a part of the body in the vicinity of or directly contacting it. The causes are thus different from those causing electric shock phenomena and are dealt with in IEC TS 62997 on magnetic nearfield safety, developed by TC 27.

The overall safety requirements for the various types of EH or EPM equipment and installations in general result from the joint application of the general requirements specified in IEC 60519-1:2015 and related particular requirements covering specific types of installations or equipment. This document complements IEC 60519-1:2015.

NOTE 2 This document complements Annex B in IEC 60519-1:2015.

On contacting, this document is based primarily on a movement of the primary contact area in relation to the live part, resulting in a contact or **touch current**. The awareness, perception and reaction times differ in comparison with a situation where a person is, for example, leaning towards or holding a conductor which subsequently becomes live, or a similar fault condition. Different considerations are then applicable and are dealt with in a detailed way in this document.

Since high impedances for dry skin will result in the lowest **touch current** and the dryness is typically variable, data for only moist and wet skin are used in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 60519-1:2015, *Safety in installations for electroheating and electromagnetic processing – Part 1: General requirements*

3 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 60519-1:2015 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>.

NOTE General definitions are given in IEC 60050, the International Electrotechnical Vocabulary. Terms relating to industrial electroheating are defined in IEC 60050-841.

3.1

aversion

experience that is disliked but can be accepted for a short time before voluntary withdrawal

Note 1 to entry: Reactions to aversive stimuli are consciously controlled, as opposed to reactions to pain which can normally not.

Note 2 to entry: The strength of an internal electric field causing muscle or nerve pain is typically twice the strength of a field causing **aversion**.

3.2

awareness

mental preparedness regarding an unpleasant experience if an object is touched, or that it can become live while being held

Note 1 to entry: Lack of **awareness** will typically delay the action of withdrawal.

3.3

electric shock

pathophysiological effect resulting from an electric current passing through a human or animal body

Note 1 to entry: The effects in the frequency range below 100 kHz are essentially immediate, as muscle and nerve reactions. In the higher frequency range, these have vanished and time-dependent local overheating can occur.

Note 2 to entry: The definition requires two contact areas, or an area of the body near a voltage source and a contact area at another potential, between which the current flows. No induced currents are supposed to be created, as with induced electric shock dealt with in IEC TS 62997.

[SOURCE IEC 60050-195:1998, 195-01-04, modified – The notes have been added.]

3.4

pain

unpleasant experience such that it is not readily accepted a second time by the subject submitted to it

EXAMPLE A capacitor discharge corresponding to 50 to $100 \times 10^{-6} \text{ A}^2\text{s}$ between gripping hands, the sting of a bee, the burn of a cigarette.

Note 1 to entry: Agents at the **pain** level cause harm as defined in for example IEC 60050-903:2013, 903-01-01.

Note 2 to entry: The examples are objective statements for standardisation purposes. Subjective experiences vary.

[SOURCE: IEC TS 60479-2:2017, 3.13, modified – The example has been rephrased, and the notes have been added.]

3.5

primary capacitive current area

accessible but insulated live conductive 100 mm × 200 mm area, or the smaller area if the accessible area is smaller

3.6

primary contact area

live part which is advertently or inadvertently touched by a part of the body closing the **touch current** circuit

3.7

prospective primary capacitive current area

part of the body in its most onerous position facing the live source

3.8

prospective touch voltage

open circuit voltage between the prospective **primary contact area** and the secondary contact area

Note 1 to entry: The effective touch voltage that is between the two parts of the body, with the active **touch current**.

Note 2 to entry: The definition differs from 195-05-09 of IEC 60050-195:1998 by the introduction of more general contact area definitions (in 3.5, 3.6 and 3.10).

3.9

reference levels

RL

directly measurable quantities, derived from basic restrictions and provided for practical exposure assessment purposes

Note 1 to entry: The meaning of the term differs between some standards and guidelines, with regard to the considerations of safety factors.

Note 2 to entry: **Reference levels** are as such not referring to any levels of immediate nerve and muscle reactions, or sensations of any gradual heating of the tissue.

Note 3 to entry: Another term, used by IEEE and EU, is action level (AL).

3.10

secondary contact area

live part or ground, with or without protective insulation, through which the current flows when the **primary contact area** is being contacted or touched, or through the **prospective primary capacitive current area**

3.11

touch current

electric current passing between the **primary contact area** or **prospective primary capacitive current area**, and the **secondary contact area**

4 Organization and use of this document

It is recommended that this document be studied in the listed order below. The order of use then depends on what is deemed to be critical. However, this document is very detailed and there are many cross-references. They are important for determining the most significant hazard condition. In particular, Annex A with its Table A.4 and Table A.5 is helpful in this respect.

- a) Clause 10 presents the basic **touch current** limitations as function of frequency up to 100 kHz, i.e. the non-thermal case of possible muscle and nerve reactions, with consideration of various situations where a **touch current** can occur. The three current level categories are shown in Figure 2. Further requirements including risk levels are given in 12.2 and Clause 14.
- b) Hazardous heating of bodyparts including skin burns are possible, in particular at frequencies higher than 100 kHz where painful muscle and nerve reaction no longer occur. The basic requirements are in Clause 11. Thermal data and further requirements including