

TECHNICAL REPORT

RAPPORT TECHNIQUE

**Effects of current on human beings and livestock –
Part 5: Touch voltage threshold values for physiological effects**

**Effets du courant sur l'homme et les animaux domestiques –
Partie 5: Valeurs des seuils de tension de contact pour les effets physiologiques**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00

TECHNICAL REPORT

RAPPORT TECHNIQUE

**Effects of current on human beings and livestock –
Part 5: Touch voltage threshold values for physiological effects**

**Effets du courant sur l'homme et les animaux domestiques –
Partie 5: Valeurs des seuils de tension de contact pour les effets physiologiques**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XA

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 Conditions and threshold values	9
4.1 General.....	9
4.2 Physiological effects of touch current	10
4.3 Body impedance.....	14
4.4 Impedance external to the body.....	15
4.5 Other factors affecting voltage thresholds	15
4.6 Touch voltage thresholds as a function of duration	16
4.7 Touch voltage thresholds for long durations	17
5 Touch voltage thresholds – Presentation of voltage-time curves	19
Annex A (informative) Body impedance.....	30
Annex B (informative) Touch voltage – Explanation of a method to derive estimates of touch voltages thresholds for strong muscular reactions and ventricular fibrillation from the body impedance tables and current limits in IEC/TS 60479-1	36
Annex C (informative) Determination of voltage thresholds under selected conditions.....	53
Annex D (informative) Limits of applicability.....	54
Bibliography.....	56
Figure 1 – Physiological thresholds for a.c. (50/60-Hz) and d.c. flowing hand-to-hand (transversely) through the human body	11
Figure 2 – Physiological thresholds for a.c. (50/60-Hz) and d.c. flowing from both hands to both feet (longitudinally) through the human body	12
Figure 3 – Physiological thresholds for a.c. (50/60-Hz) and d.c. flowing from hand-to-seat (longitudinal) through the human body	13
Figure 4 – Flow chart to be used for the selection of the appropriate figure providing the maximum duration for each touch voltage threshold.....	17
Figure 5 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for saltwater-wet condition and large contact area.....	20
Figure 6 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for saltwater-wet condition and medium contact area	21
Figure 7 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for saltwater-wet condition and small contact area	21
Figure 8 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for water-wet condition and large contact area	22
Figure 9 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for water-wet condition and medium contact area.....	22
Figure 10 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for water-wet condition and small contact area	23

Figure 11 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for dry condition and large contact area	23
Figure 12 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for dry condition and medium contact area	24
Figure 13 – Conventional time/voltage zones of effects of a.c. current (50/60 Hz) on a person for dry condition and small contact area	24
Figure 14 – Conventional time/voltage zones of effects of d.c. current on a person for saltwater-wet condition and large contact area	25
Figure 15 – Conventional time/voltage zones of effects of d.c. current on a person for saltwater-wet condition and medium contact area	25
Figure 16 – Conventional time/voltage zones of effects of d.c. current on a person for saltwater-wet condition and small contact area	26
Figure 17 – Conventional time/voltage zones of effects of d.c. current on a person for water-wet condition and large contact area	26
Figure 18 – Conventional time/voltage zones of effects of d.c. current on a person for water-wet condition and medium contact area	27
Figure 19 – Conventional time/voltage zones of effects of d.c. current on a person for water-wet condition and small contact area	27
Figure 20 – Conventional time/voltage zones of effects of d.c. current on a person for dry condition and large contact area	28
Figure 21 – Conventional time/voltage zones of effects of d.c. current on a person for dry condition and medium contact area	28
Figure 22 – Conventional time/voltage zones of effects of d.c. current on a person for dry condition and small contact area	29
Figure A.1 – Model for hand-to-hand contact	33
Figure A.2 – Model for both-hands-to-feet contact	34
Figure A.3 – Model for hand-to-seat contact	35
Figure B.1 – Estimation of the variation of the skin resistance as a function of electric shock duration	38
Figure B.2 – Example of extrapolation of the hand-to-hand body impedance at 0 V in dry conditions with large contact area	42
Figure B.3 – Percentage of internal resistance of the human body for the part of the body concerned	43
Figure B.4 – Example of diagram for the estimation of the strong muscular reactions and ventricular fibrillation threshold for a.c. current hand-to-hand current path, large contact area and dry condition for a current duration of 10 ms	47
Table 1 – Current threshold values for each condition and for long duration	14
Table 2 – Tables providing minimum touch voltage threshold for a.c. and d.c. corresponding to startle reaction, strong muscular reaction and ventricular fibrillation (see Table 1 notes)	18
Table 2a – Startle reaction for alternating current 50/60 Hz	18
Table 2b – Strong muscular reaction for alternating current 50/60 Hz	18
Table 2c – Ventricular fibrillation for alternating current 50/60 Hz	18
Table 2d – Startle reaction for direct current	19
Table 2e – Strong muscular reaction for direct current	19
Table 2f – Ventricular fibrillation for direct current	19
Table A.1 – Total body impedance in ohms for dry, hand-to-hand, 50/60 Hz a.c., large surface area contact (IEC/TS 60479-1 Table 1)	31

Table A.2 – Total body impedance in ohms for dry, hand-to-hand, d.c., large surface area contact (IEC/TS 60479-1 Table 10).....	31
Table B.1 – Nature and number of the parameters influencing the human body impedance which are taken into consideration by IEC/TS 60479-1.....	37
Table B.2 – Additional parameters influencing the human body impedance.....	37
Table B.3 – Maximum a.c. current threshold corresponding to current flow duration for each current effect considered and for a hand-to-hand current path.....	46
Table B.4 – Maximum a.c. current threshold corresponding to current flow duration for each current effect considered for both-hands-to-feet current path.....	47
Table B.5 – Maximum a.c. current threshold corresponding to current flow duration for each current effect considered for a hand-to-seat current path.....	48
Table B.6 – Maximum d.c. current threshold corresponding to current flow duration for each current effect considered for the hand-to-hand current path.....	51
Table B.7 – Maximum d.c. current threshold corresponding to current flow duration for each current effect considered for the both-hands-to-feet current path.....	52
Table B.8 – Maximum d.c. current threshold corresponding to current flow duration for each current effect considered for the hand-to-seat current path.....	52
Table C.1 – Example of touch voltage thresholds for a.c. and d.c. corresponding to muscular effects and ventricular fibrillation for the above specified environmental situations	53

preview generated by EVS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –**Part 5: Touch voltage threshold values for physiological effects**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 60479-5, which is a technical report, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
64/1585/DTS	64/1611/RVC

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

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

A list of all the parts in the IEC 60479 series, under the general title *Effects of current on human beings and livestock*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This technical report provides a methodology for estimating voltage thresholds which are intended to give guidance to IEC technical committees on the selection and application of voltage limits with regard to protection against electric shock. Technical committees may use this methodology to recalculate proposed voltage thresholds or to determine new voltage threshold values based on different pathways, other current threshold values, different alternating current frequencies, other skin capacitances values, etc.

To estimate the type and severity of physiological effects that might be caused by electricity, the magnitude and pathway of current through a person's body needs to be determined. However, from an equipment design point of view, it is advantageous to be able to predict whether unwanted physiological effects are possible or probable, given only information about voltage levels on accessible conductive surfaces. If the maximum available voltage is sufficiently low under the expected circumstances to be unable to cause enough touch current to cause unwanted physiological effects, then the safeguards normally required to avoid the occurrence of these physiological effects may be reduced or eliminated. Voltages below critical levels that are unlikely to be hazardous in this respect have normally been called extra-low voltage (ELV). Based on this information technical committees may wish to review their defined values of extra-low voltage.

The objective of this technical report being to derive touch voltage threshold values corresponding to zones of physiological effects (as presented in Figures 20 and 22 of IEC/TS 60479-1), the introduction of such techniques gives designers the ability to provide a larger variety of circuits that give the expected level of user protection under a broader set of circumstances than previously considered.

The physiological effects corresponding to the threshold voltage values should be the same as those for touch current that appear in IEC/TS 60479-1. Physiological effects considered in this technical report are startle reaction of current, effects involving muscular contractions such as inability to let-go and ventricular fibrillation. Current thresholds are based on curves a, b and c₁ in IEC/TS 60479-1 which remains the prime standard. The touch voltage thresholds are related to the touch current thresholds by the body impedance according to Ohm's law. However, in this case, the application of Ohm's law is not straightforward. Body impedance is a function of a number of variables including the voltage across the body, the current pathway, the area of contact between the skin and the conductive surface, the level of moisture in the contact area, and the duration of voltage across (or current through) the body. When voltage is applied to the body and current begins to flow, the resistive component of the skin impedance changes to a lower value within a few tens of milliseconds.

This technical report discusses 50/60Hz sinusoidal alternating voltage and pure direct voltage having no significant alternating component. Higher frequency alternating voltage is not included in this type of analysis as this would require a more complex body impedance model and would require the use of frequency factors for the current thresholds for the unwanted physiological effects. As this technical report does not cover frequencies above 50/60Hz, technical committees are requested to inform IEC/TC 64 about experience gained on this subject. Suggestions for modifications and additions to the report should be submitted to IEC/TC 64.

This work does not relieve the responsibility of IEC technical committees to consider the usual touch current commonly measured in product evaluations.

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 5: Touch voltage threshold values for physiological effects

1 Scope

IEC/TR 60479-5, which is a technical report, provides touch voltage-duration combination thresholds based on analysis of information concerning body impedances and current thresholds of physiological effects, as given in IEC/TS 60479-1. Such threshold combinations relate to specific environmental and contact conditions that determine body impedance for particular current pathways.

This technical report considers only

- (i) 50/60 Hz sinusoidal alternating voltage having no other frequency components and no significant direct voltage component, and
- (ii) direct voltage with no significant alternating component.

This technical report provides thresholds as a result of calculations based on values from IEC/TS 60479-1, with uncertainties. Therefore thresholds proposed in this report also correspond to values with uncertainties.

This technical report does not consider immersion of body parts and medical application.

Touch voltage-duration combination thresholds are for use by technical committees as guidance for the determination of limits for touch voltage and touch voltage durations in various environmental situations.

Determination of limits needs to be based on risk assessment. Factors that are part of risk assessment include voltage threshold values (taking into account contact area, skin moisture condition, body current pathway) provided by this technical report, as well as other factors not covered such as:

- reduction of the likelihood of contact (by obstacles, barriers, warnings, placing out of reach, training, etc.); or
- reduction of touch voltage compared to the fault voltage (such as by equipotential bonding); or
- additional resistance in series with the human body (such as gloves, shoes, carpet, etc.).

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.

IEC 60050-195, *International Electrotechnical Vocabulary – Part 195: Earthing and protection against electric shock*

IEC/TS 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60990, *Methods of measurement of touch current and protective conductor current*