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IEC TS 60479-1

Edition 4.1 2016-07
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TECHNICAL SPECIFICATION

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BASIC SAFETY PUBLICATION

Effects of current on human beings and livestock – Part 1: General aspects

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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BASIC SAFETY PUBLICATION

Effects of current on human beings and livestock – Part 1: General aspects

IEC TS 60479-1:2005-07+AMD1:2016-07 CSV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 1: General aspects

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.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC TS 60479-1 edition 4.1 contains the fourth edition (2005-07) [documents 64/1427/DTS and 64/1463/RVC] and its amendment 1 (2016-07) [documents 64/2095/DTS and 64/2113/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC 60479-1, which is a technical specification, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition cancels and replaces the third edition, published as a technical report in 1994, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– Dependence of the total body impedance Z_T for 50th percentile rank of a population of living human beings for large, average and small surface areas of a contact in dry, water-wet and saltwater-wet conditions at touch voltage U_T = 25 V to 200 V a.c. 50/60 Hz.
– Oscillograms of touch voltages U_T and touch currents I_T for a.c., current path hand-to-hand, large surface areas of contact in dry condition taken from measurements given in Figure 16 with the relevant explanations in the main text.
– Fibrillation data for dogs, pigs and sheep obtained from experiments and for persons calculated from statistics of electrical accidents with transversal direction of current flow, hand-to-hand and touch voltages U_T = 220 V to 380 V a.c.with body impedances Z_T (5%) given in Figure 19 with the relevant explanations in the main text.
– Change of Curve B in Figure 20 from 10 mA to 5 mA: conventional time/current zones of effects of a.c. current (15 Hz to 100 Hz) on persons with the relevant explanations in themain text.
– Let-go currents for 60 Hz sinusoidal current given in Figure 23 with the relevant explanations in the main text.
– new structure to the body of the standard.
– Extension of the applicability of the total body impedance to a frequency range up to 150 kHz;
– Clarification of the difference in anodic versus cathodic d.c. pulses;
– Extension of the ventricular fibrillation threshold of single pulses down to 1 μs pulse width;
– Addition of informative annexes:

  Annex E: Theories of ventricular fibrillation;

  Annex F: Quantities ULV and LLV;

  Annex G: Circuit simulation methods in electric shock evaluation.

This technical specification has the status of a basic safety publication in accordance with IEC Guide 104.

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

Enquiry draft	Report on voting
64/1427/DTS	64/1463/RVC

Full information on the voting for the approval of this technical specification 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.

IEC 60479 consists of the following parts under the general title *Effects of current on human beings and livestock*

Part 1: General aspects

Part 2: Special aspects:

Chapter 4: Effects of alternating current with frequencies above 100 Hz

Chapter 5: Effects of special waveforms of current

Chapter 6: Effects of unidirectional single impulse currents of short duration

Part 3: Effects of currents passing through the bodies of livestock

Part 4: Effects of lightning strokes on human beings and livestock

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability 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.

A bilingual version of this publication may be issued at a later date.

The contents of the corrigendum of October 2006 and June 2013 have been included in this copy.

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INTRODUCTION

This basic safety publication is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51. It is not intended for use by manufacturers or certification bodies.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications.

This technical specification provides basic guidance on the effects of shock current on human beings and livestock, for use in the establishment of electrical safety requirements.

In order to avoid errors in the interpretation of this technical specification, it ~~must~~ should be emphasized that the data given herein is mainly based on experiments with animals as well as on information available from clinical observations. Only a few experiments with shock currents of short duration have been carried out on living human beings.

On the evidence available, mostly from animal research, the values are so conservative that ~~the standard~~ this document applies to persons of normal physiological conditions including children, irrespective of age and weight.

There are, however, other aspects to be taken into account, such as probability of faults, probability of contact with live or faulty parts, ratio between touch voltage and fault voltage, experience gained, technical feasibilities, and economics. These parameters ~~have to~~ should be considered carefully when fixing safety requirements, for example, operating characteristics of protective devices for electrical installations.

The form of the ~~specification~~ document as has been adopted summarizes results so far achieved which are being used by technical committee 64 as a basis for fixing requirements for protection against shock. These results are considered important enough to justify an IEC publication which may serve as a guide to other IEC committees and countries having need of such information.

This technical specification applies to the threshold of ventricular fibrillation which is the main cause of deaths by electric current. The analysis of results of recent research work on cardiac physiology and on the fibrillation threshold, taken together, has made it possible to better appreciate the influence of the main physical parameters and, especially, of the duration of the current flow.

IEC TS 60479-1 contains information about body impedance and body current thresholds for various physiological effects. This information can be combined to derive estimates of a.c. and d.c. touch voltage thresholds for certain body current pathways, contact moisture conditions, and skin contact areas. ~~Information about touch voltage thresholds for physiological effects is contained in the IEC 61201.~~

This technical specification refers specifically to the effects of electric current. When an assessment of the harmful effects of any event on human beings and livestock is being made, other non-electric phenomena, including falls, heat, fire, or others should be taken into account. These matters are beyond the scope of this technical specification, but may be extremely serious in their own right.

~~Recent research work has also been conducted on the other physical accident parameters, especially the waveform and frequency of the current and the impedance of the human body. This fourth revision of IEC 60479-1 should be viewed as the logical development and evolution of the third edition.~~

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~~Clause 2 of IEC 60479-1 (third edition) on the impedance of the human body contained little information on the dependence of the impedance on the surface area of contact and then only for dry conditions.~~

~~Therefore measurements were carried out on 10 persons using medium and small surface areas of contact in dry, water-wet and saltwater-wet conditions, current path hand to hand, at a touch voltage of 25 V a.c. 50 Hz. The impedance values for a percentile rank of 5 %, 50 % and 95 % have been calculated from these measurements.~~

~~Due to unpleasant sensations and the possibility of inherent danger, measurements using large surface areas of contact (order of magnitude 10 000 mm^2) in dry, water-wet and saltwater-wet conditions and with medium and small surface areas of contact (order of magnitude 1 000 mm^2 and 100 mm^2) in dry condition at touch voltages from 25 V up to and including 200 V a.c. have only been carried out on one person. By the use of deviation factors it was nevertheless possible to derive values of the total body impedance Z_T for a percentile rank of 5 %, 50 % and 95 % of a population of persons. With the same one person measurements were also made with still smaller surface areas of contact (10 mm^2 and 1 mm^2) and between fingertips.~~

~~For the calculation of total body impedance Z_T for a percentile rank of 5 %, 50 % and 95 % of a population of persons for large surface areas of contact for touch voltages above 200 V up to 700 V and higher up to the asymptotic values the method to adapt values of Z_T measured on corpses to those of persons used for the second edition of IEC 60479-1 was improved by taking account of the different temperature of the corpses during measurements and the temperature of 37 °C for persons.~~

~~The present state of knowledge of a.c. impedance Z_T of the human body for large, medium and small surface areas of contact in dry, water-wet and salt-water-wet conditions and of the d.c. resistance R_T of the human body for large areas of contact in dry conditions are presented.~~

~~It should be mentioned that the thresholds as order of magnitude are valid for all persons (men, women and children) independent of their state of health. Often concerns are expressed in that respect but if the background of such objections is examined it is found that such objections represent just opinions without experimental evidence. Some measurements indicate that the thresholds of perception and let-go for women are lower than for men. This may also be the case for children.~~

~~Furthermore in Clause 5 a heart-current factor F for the current path foot to foot has been introduced. This is important for electrical risks caused by step voltages.~~

Further experimental data are under consideration, such as recent ongoing experimental work on "current induced heart fibrillation by excitation with discrete Fourier spectra" which is intended to contribute to frequency factor data.

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 1: General aspects

1 Scope

For a given current path through the human body, the danger to persons depends mainly on the magnitude and duration of the current flow. However, the time/current zones specified in the following clauses are, in many cases, not directly applicable in practice for designing measures of protection against electrical shock. The necessary criterion is the admissible limit of touch voltage (i.e. the product of the current through the body called touch current and the body impedance) as a function of time. The relationship between current and voltage is not linear because the impedance of the human body varies with the touch voltage, and data on this relationship is therefore required. The different parts of the human body (such as the skin, blood, muscles, other tissues and joints) present to the electric current a certain impedance composed of resistive and capacitive components.

The values of body impedance depend on a number of factors and, in particular, on current path, on touch voltage, duration of current flow, frequency, degree of moisture of the skin, surface area of contact, pressure exerted and temperature.

The impedance values indicated in this technical specification result from a close examination of the experimental results available from measurements carried out principally on corpses and on some living persons.

Knowledge of the effects of alternating current is primarily based on the findings related to the effects of current at frequencies of 50 Hz or 60 Hz which are the most common in electrical installations. The values given are, however, deemed applicable over the frequency range from 15 Hz to 100 Hz, threshold values at the limits of this range being higher than those at 50 Hz or 60 Hz. Principally the risk of ventricular fibrillation is considered to be the main mechanism of death of fatal electrical accidents.

Accidents with direct current are much less frequent than would be expected from the number of d.c. applications, and fatal electrical accidents occur only under very unfavourable conditions, for example, in mines. This is partly due to the fact that with direct current, the let-go of parts gripped is less difficult and that for shock durations longer than the period of the cardiac cycle, the threshold of ventricular fibrillation is considerably higher than for alternating current.

NOTE The IEC 60479 series contains information about body impedance and body current thresholds for various physiological effects. This information can be combined to derive estimates of a.c. and d.c. touch voltage thresholds for certain body current pathways, contact moisture conditions, and skin contact areas. Information about touch voltage thresholds for physiological effects is contained in IEC 61201.

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 61201:1992, *Extra-low voltage (ELV) – Limit values*

Guide 104:1997, *The preparation of safety publications and the use of basic safety publications and group safety publications*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 1: General aspects

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC TS 60479-1 edition 4.1 contains the fourth edition (2005-07) [documents 64/1427/DTS and 64/1463/RVC] and its amendment 1 (2016-07) [documents 64/2095/DTS and 64/2113/RVC].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC 60479-1, which is a technical specification, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition cancels and replaces the third edition, published as a technical report in 1994, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– Dependence of the total body impedance Z_T for 50th percentile rank of a population of living human beings for large, average and small surface areas of a contact in dry, water-wet and saltwater-wet conditions at touch voltage U_T = 25 V to 200 V a.c. 50/60 Hz.
– Oscillograms of touch voltages U_T and touch currents I_T for a.c., current path hand-to-hand, large surface areas of contact in dry condition taken from measurements given in Figure 16 with the relevant explanations in the main text.
– Fibrillation data for dogs, pigs and sheep obtained from experiments and for persons calculated from statistics of electrical accidents with transversal direction of current flow, hand-to-hand and touch voltages U_T = 220 V to 380 V a.c.with body impedances Z_T (5%) given in Figure 19 with the relevant explanations in the main text.
– Change of Curve B in Figure 20 from 10 mA to 5 mA: conventional time/current zones of effects of a.c. current (15 Hz to 100 Hz) on persons with the relevant explanations in themain text.
– Let-go currents for 60 Hz sinusoidal current given in Figure 23 with the relevant explanations in the main text.
– new structure to the body of the standard.
– Extension of the applicability of the total body impedance to a frequency range up to 150 kHz;
– Clarification of the difference in anodic versus cathodic d.c. pulses;
– Extension of the ventricular fibrillation threshold of single pulses down to 1 μs pulse width;
– Addition of informative annexes:

  Annex E: Theories of ventricular fibrillation;

  Annex F: Quantities ULV and LLV;

  Annex G: Circuit simulation methods in electric shock evaluation.

This technical specification has the status of a basic safety publication in accordance with IEC Guide 104.

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

Enquiry draft	Report on voting
64/1427/DTS	64/1463/RVC

Full information on the voting for the approval of this technical specification 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.

IEC 60479 consists of the following parts under the general title *Effects of current on human beings and livestock*

Part 1: General aspects

Part 2: Special aspects:

Chapter 4: Effects of alternating current with frequencies above 100 Hz

Chapter 5: Effects of special waveforms of current

Chapter 6: Effects of unidirectional single impulse currents of short duration

Part 3: Effects of currents passing through the bodies of livestock

Part 4: Effects of lightning strokes on human beings and livestock

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability 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.

A bilingual version of this publication may be issued at a later date.

The contents of the corrigendum of October 2006 and June 2013 have been included in this copy.

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INTRODUCTION

This basic safety publication is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51. It is not intended for use by manufacturers or certification bodies.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications.

This technical specification provides basic guidance on the effects of shock current on human beings and livestock, for use in the establishment of electrical safety requirements.

In order to avoid errors in the interpretation of this technical specification, it should be emphasized that the data given herein is mainly based on experiments with animals as well as on information available from clinical observations. Only a few experiments with shock currents of short duration have been carried out on living human beings.

On the evidence available, mostly from animal research, the values are so conservative that this document applies to persons of normal physiological conditions including children, irrespective of age and weight.

There are, however, other aspects to be taken into account, such as probability of faults, probability of contact with live or faulty parts, ratio between touch voltage and fault voltage, experience gained, technical feasibilities, and economics. These parameters should be considered carefully when fixing safety requirements, for example, operating characteristics of protective devices for electrical installations.

The form of the document as has been adopted summarizes results so far achieved which are being used by technical committee 64 as a basis for fixing requirements for protection against shock. These results are considered important enough to justify an IEC publication which may serve as a guide to other IEC committees and countries having need of such information.

This technical specification applies to the threshold of ventricular fibrillation which is the main cause of deaths by electric current. The analysis of results of recent research work on cardiac physiology and on the fibrillation threshold, taken together, has made it possible to better appreciate the influence of the main physical parameters and, especially, of the duration of the current flow.

IEC TS 60479-1 contains information about body impedance and body current thresholds for various physiological effects. This information can be combined to derive estimates of a.c. and d.c. touch voltage thresholds for certain body current pathways, contact moisture conditions, and skin contact areas.

This technical specification refers specifically to the effects of electric current. When an assessment of the harmful effects of any event on human beings and livestock is being made, other non-electric phenomena, including falls, heat, fire, or others should be taken into account. These matters are beyond the scope of this technical specification, but may be extremely serious in their own right.

Further experimental data are under consideration, such as recent ongoing experimental work on "current induced heart fibrillation by excitation with discrete Fourier spectra" which is intended to contribute to frequency factor data.

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 1: General aspects

1 Scope

For a given current path through the human body, the danger to persons depends mainly on the magnitude and duration of the current flow. However, the time/current zones specified in the following clauses are, in many cases, not directly applicable in practice for designing measures of protection against electrical shock. The necessary criterion is the admissible limit of touch voltage (i.e. the product of the current through the body called touch current and the body impedance) as a function of time. The relationship between current and voltage is not linear because the impedance of the human body varies with the touch voltage, and data on this relationship is therefore required. The different parts of the human body (such as the skin, blood, muscles, other tissues and joints) present to the electric current a certain impedance composed of resistive and capacitive components.

The values of body impedance depend on a number of factors and, in particular, on current path, on touch voltage, duration of current flow, frequency, degree of moisture of the skin, surface area of contact, pressure exerted and temperature.

The impedance values indicated in this technical specification result from a close examination of the experimental results available from measurements carried out principally on corpses and on some living persons.

Knowledge of the effects of alternating current is primarily based on the findings related to the effects of current at frequencies of 50 Hz or 60 Hz which are the most common in electrical installations. The values given are, however, deemed applicable over the frequency range from 15 Hz to 100 Hz, threshold values at the limits of this range being higher than those at 50 Hz or 60 Hz. Principally the risk of ventricular fibrillation is considered to be the main mechanism of death of fatal electrical accidents.

Accidents with direct current are much less frequent than would be expected from the number of d.c. applications, and fatal electrical accidents occur only under very unfavourable conditions, for example, in mines. This is partly due to the fact that with direct current, the let-go of parts gripped is less difficult and that for shock durations longer than the period of the cardiac cycle, the threshold of ventricular fibrillation is considerably higher than for alternating current.

NOTE The IEC 60479 series contains information about body impedance and body current thresholds for various physiological effects. This information can be combined to derive estimates of a.c. and d.c. touch voltage thresholds for certain body current pathways, contact moisture conditions, and skin contact areas. Information about touch voltage thresholds for physiological effects is contained in IEC 61201.

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 61201:1992, *Extra-low voltage (ELV) – Limit values*

Guide 104:1997, *The preparation of safety publications and the use of basic safety publications and group safety publications*

Withdrawn