

STN	Účinky prúdu na ľudí a hospodárske zvieratá Časť 2: Osobitné hľadiská	STN IEC 60479-2 33 2011
------------	--	---

idt IEC 60479-2: 2019

Effects of current on human beings and livestock
Part 2: Special aspects

Effets du courant sur l'homme et les animaux domestiques
Partie 2: Aspects spéciaux

Wirkungen des elektrischen Stromes auf Menschen und Nutztiere
Teil 2: Besondere Aspekte

Táto norma obsahuje anglickú verziu IEC 60479-2: 2019.

This standard includes the English version of IEC 60479-2: 2019.

129287

Anotácia

Táto časť súboru IEC 60479 opisuje účinky na ľudské telo, ak ním prechádza sínusový striedavý prúd v rozsahu frekvencií nad 100 Hz.

Uvádza sa účinky prúdu prechádzajúceho ľudským telom pre

- striedavý sínusový prúd s jednosmernými zložkami,
- striedavý sínusový prúd s fázovým riadením, a
- striedavý sínusový prúd s cyklovým riadením,

avšak považujú sa za použiteľné len pre striedavý prúd s frekvenciami od 15 Hz do 100 Hz.

Uvádza sa možnosti/spôsoby rozšírenia použiteľnosti čistých sínusoid do frekvencie 150 kHz, ktoré dopĺňajú údaje v norme IEC 60479-1.

Uvádza sa spôsoby skúmania náhodných komplexných nepravidelných tvarov vln.

Tento dokument opisuje účinky prúdu prechádzajúceho ľudským telom vo forme jednorazových a viacnásobných jednosmerných pravouhlých impulzov, sínusových impulzov a vo forme impulzov vznikajúcich následkom vybíjania kondenzátora.

Uvádzané hodnoty sa považujú za použiteľné pre trvanie impulzov od 0,1 ms do 10 ms vrátane.

Tento dokument, rovnako ako IEC 60479-1, berie do úvahy iba prúd pretekajúci telom v dôsledku priameho pôsobenia zdroja prúdu na telo. Neberie do úvahy prúd indukovaný v tele, spôsobený vystavením tela vonkajšiemu elektromagnetickému poľu.

Táto základná bezpečnostná publikácia je primárne určená na použitie technickými komisiami pri príprave noriem v súlade so zásadami stanovenými v príručke IEC Guide 104 a príručke ISO/IEC Guide 51. Nie je určená na použitie výrobcami alebo certifikačnými orgánmi.

Jednou z povinností technickej komisie je, kdekoľvek je možné to uplatniť, využívať pri príprave svojich publikácií základné bezpečnostné publikácie. Požiadavky, skúšobné metódy alebo skúšobné podmienky tejto základnej bezpečnostnej publikácie sa neuplatňujú, pokiaľ sa na ne v príslušných publikáciách výslovne neodkazuje, alebo nie sú v nich obsiahnuté.

Národný predhovor

Obrázky v tejto norme sú prevzaté z elektronických podkladov dodaných z IEC, © 2019 IEC, ref. č. IEC 60479-2: 2019.

Normatívne referenčné dokumenty

Nasledujúce dokumenty, celé alebo ich časti, sú v tomto dokumente normatívnymi odkazmi a sú nevyhnutné pri jeho používaní. Pri datovaných odkazoch sa použije len citované vydanie. Pri nedatovaných odkazoch sa použije najnovšie vydanie citovaného dokumentu (vrátane všetkých zmien).

POZNÁMKA 1. – Ak bola medzinárodná publikácia zmenená spoločnými modifikáciami, čo je indikované označením (mod), použije sa príslušná EN/HD.

POZNÁMKA 2. – Aktuálne informácie o platných a zrušených STN možno získať na webovej stránke www.unms.sk.

Prehľad normatívnych referenčných dokumentov:

Medzinárodná norma	Európska norma	STN	Triediaci znak
IEC 60479-1: 2018	–	STN IEC 60479-1: 2019	33 2011
IEC 60990	EN 60990	STN EN 60990	33 2020
pokyn IEC Guide 104: 2010	–	–	–
pokyn ISO/IEC Guide 51: 2014	–	–	–

Názvy normatívnych referenčných dokumentov prevzatých do STN:

STN IEC 60479-1 Účinky prúdu na ľudí a hospodárske zvieratá. Časť 1: Všeobecné hľadiská

STN EN 60990 Metódy merania dotykového prúdu a prúdu tečúceho ochranným vodičom

Vypracovanie normy

Spracovateľ: Úrad pre normalizáciu, metrológiu a skúšobníctvo SR

Technická komisia: TK 84 Elektrické inštalácie a ochrana pred zásahom elektrickým prúdom



IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications* Edition 1.0 2019-05

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

INTERNATIONAL STANDARD



BASIC SAFETY PUBLICATION

Effects of current on human beings and livestock – Part 2: Special aspects





IEC 60990, *Methods of measurement of touch current and protective conductor current*
THIS PUBLICATION IS COPYRIGHT PROTECTED
 Copyright © 2019 IEC, Geneva, Switzerland
 IEC Guide 104, *The preparation of safety publications and the use of basic safety*
 publications and group safety publications
 ISO/IEC Guide 51, *Safety aspects - Guidelines for their inclusion in standards*
 IEC Guide 51, *Safety aspects - Guidelines for their inclusion in standards*
 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 have an enquiry about obtaining permission to use the publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
 3, rue de Varembe
 CH-1211 Geneva 20
 Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

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

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.



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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

INTERNATIONAL STANDARD



BASIC SAFETY PUBLICATION

Effects of current on human beings and livestock – Part 2: Special aspects

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.200; 29.020

ISBN 978-2-8322-6689-2

Warning! Make sure that you obtained this publication from an authorized distributor.

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

CONTENTS	
IEC Guide 104, <i>The preparation of safety publications and the use of basic safety publications and group safety publications</i>	5
FOREWORD.....	
INTRODUCTION.....	7
ISO/IEC Guide 51, <i>Safety aspects – Guidelines for their inclusion in standards</i>	8
1 Scope.....	
2 Normative references	8
3 Terms and definitions	9
4 Effects of alternating currents with frequencies above 100 Hz	11
4.1 General.....	11
4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz	12
4.2.1 Threshold of perception	12
4.2.2 Threshold of let-go	12
4.2.3 Threshold of ventricular fibrillation	13
4.3 Effects of alternating current in the frequency range above 1 000 Hz up to and including 10 000 Hz.....	14
4.3.1 Threshold of perception	14
4.3.2 Threshold of let-go	14
4.3.3 Threshold of ventricular fibrillation	15
4.4 Effects of alternating current in the frequency range above 10 000 Hz	15
4.4.1 General	15
4.4.2 Threshold of perception	15
4.4.3 Threshold of let-go	15
4.4.4 Threshold of ventricular fibrillation	15
4.4.5 Other effects.....	16
5 Effects of special waveforms of current	16
5.1 General.....	16
5.2 Equivalent magnitude, frequency and threshold	16
5.3 Effects of alternating current with DC components	17
5.3.1 Waveforms and frequencies and current thresholds.....	17
5.3.2 Threshold of startle reaction	18
5.3.3 Threshold of let-go	19
5.3.4 Threshold of ventricular fibrillation	20
6 Effects of alternating current with phase control	24
6.1 Waveforms and frequencies and current thresholds	24
6.2 Threshold of startle reaction and threshold of let-go.....	25
6.3 Threshold of ventricular fibrillation	25
6.3.1 General	25
6.3.2 Symmetrical control	26
6.3.3 Asymmetrical control	26
7 Effects of alternating current with multicyle control	26
7.1 Waveforms and frequencies	26
7.2 Threshold of startle reaction and threshold of let-go.....	27
7.3 Threshold of ventricular fibrillation	27
7.3.1 General	27
7.3.2 Shock durations longer than 1,5 times the period of the cardiac cycle	28
7.3.3 Shock durations less than 0,75 times the period of the cardiac cycle	28

IEC 60990 Methods of measurement of threshold and protective conductor current	28
8.1 Threshold of perception and let-go	28
IEC Guide 104 The preparation of safety publications and the use of basic safety publications and group safety publications	29
8.2 Threshold of ventricular fibrillation	29
9 Effects of current pulse bursts and random complex irregular waveforms	29
ISO IEC Guide 51, safety aspects – Guidelines for the use of IEC standards	29
9.1 Ventricular fibrillation threshold of multiple pulses of current separated by 300 ms or more	29
9.2 Ventricular fibrillation threshold of multiple pulses of current separated by less than 300 ms	29
9.2.1 General	29
9.2.2 Examples	30
9.2.3 Random complex irregular waveforms	32
10 Effects of electric current through the immersed human body	34
10.1 General	34
10.2 Resistivity of water solutions and of the human body	34
10.3 Conducted current through immersed body	36
10.4 Physiological effects of current through the immersed body	37
10.5 Threshold values of current	38
10.6 Intrinsically “safe” voltage values	38
11 Effects of unidirectional single impulse currents of short duration	38
11.1 General	38
11.2 Effects of unidirectional impulse currents of short duration	39
11.2.1 Waveforms	39
11.2.2 Determination of specific fibrillating energy F_e	40
11.3 Threshold of perception and threshold of pain for capacitor discharge	41
11.4 Threshold of ventricular fibrillation	43
11.4.1 General	43
11.4.2 Examples	44
Annex A (informative) Random complex irregular waveform analysis	47
A.1 General	47
A.2 Formal theoretical statement of the method	47
A.3 Demonstration of the calculation	48
A.3.1 General	48
A.3.2 Choice of justified current	50
A.3.3 Choice of sampling step size	50
A.4 Examples 1 and 2	51
Bibliography	54
Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz	12
Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz	13
Figure 3 – Variation of the threshold of ventricular fibrillation within the frequency range 50/60 Hz to 1 000 Hz, shock durations longer than one heart period and longitudinal current paths through the trunk of the body	13
Figure 4 – Variation of the threshold of perception within the frequency range 1 000 Hz to 10 000 Hz	14
Figure 5 – Variation of the threshold of let-go within the frequency range 1 000 Hz to 10 000 Hz	14

Figure 6 – Methods of the measurement of ventricular fibrillation protective conductor current (1 000 Hz to 150 kHz)	16
Figure 7 – Waveforms of currents	18
Figure 8 – Let-go thresholds for men, women and children	19
Figure 9 – 99.5 percentile let-go threshold for combinations of 50/60 Hz sinusoidal alternating current and direct current	20
Figure 10 – Composite alternating and direct current with equivalent likelihood of ventricular fibrillation.....	22
Figure 11 – Waveforms of rectified alternating currents	23
Figure 12 – Waveforms of alternating currents with phase control.....	25
Figure 13 – Waveforms of alternating currents calculated with multicycle control factor	27
Figure 14 – Threshold of ventricular fibrillation (average value) for alternating current with multicycle control for various degrees of controls (results of experiments with young pigs).....	28
Figure 15 – Series of four rectangular pulses of unidirectional current	31
Figure 16 – Series of four rectangular pulses of unidirectional current	31
Figure 17 – Series of four rectangular pulses of unidirectional current	32
Figure 18 – Example of current versus elapsed time over a contaminated insulator	33
Figure 19 – PC plotted on the AC time current curves (IEC 60479-1:2018, Figure 20).....	34
Figure 20 – Forms of current for rectangular impulses, sinusoidal impulses and for capacitor discharges	40
Figure 21 – Rectangular impulse, sinusoidal impulse and capacitor discharge having the same specific fibrillating energy and the same shock duration.....	41
Figure 22 – Threshold of perception and threshold of pain for the current resulting from the discharge of a capacitor (dry hands, large contact area)	42
Figure 23 – Probability of fibrillation risks for current flowing in the path left hand to feet	44
Figure A.1 – Definition of a segment of a random complex waveform.....	47
Figure A.2 – Definition of a duration within a sample.....	47
Figure A.3 – PC for demonstration example of the random complex waveform method plotted against time-current curves for RMS AC.....	50
Figure A.4 – Random complex waveform typical of those used in Example 1	51
Figure A.5 – Random complex waveform typical of those used in Example 2	52
Figure A.6 – PC for Examples 1 and 2 of the random complex waveform method plotted against time-current curves for RMS AC.....	53
Table 1 – Estimate for ventricular fibrillation threshold after each pulse of current in a series of pulses each of which excited the heart tissue in such a manner as to trigger ventricular responses.....	30
Table 2 – Resistivity of water solutions [24], [25]	35
Table 3 – Resistivity of human body tissues.....	36
Table 4 – Relative interaction between the resistivity of water solution and the impedance characteristic of the electrical source	37
Table 5 – Effects of shocks.....	45
Table 6 – Effects of shocks.....	46

INTERNATIONAL ELECTROTECHNICAL COMMISSION
 IEC 60990, *Measurement of electromagnetic interference current*

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

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

Part 2: Special 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.
- 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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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.

International Standard IEC 60479-2 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This first edition cancels and replaces IEC TS 60479-2:2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 60479-2:2017:

- a) change in status from Technical Specification to International Standard.

It has the status of a basic safety publication in accordance with IEC Guide 104.

~~IEC 60479-2:2019, Methods of measurement of base current for protective conductor current~~

IEC Guide 104, <i>The preparation of safety publications and the use of basic safety publications and group safety publications</i>	GDV 64/2362/SD	Report on voting 64/2362/RVC
---	-------------------	---------------------------------

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*
Full information on the voting for the approval of this International Standard 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.

A list of all parts in the IEC 60479 series, published 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 document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

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

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

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

INTRODUCTION

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and general safety publications*, emphasizes that the data given here are 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 humans for their inclusion in standards

The effects of current passing through the human body for

- alternating sinusoidal current with DC components,
- alternating sinusoidal current with phase control,
- alternating sinusoidal current with multicycle control,
- equivalent current threshold for mixed frequencies,
- current pulse bursts and random complex irregular waveforms,
- electric current through the immersed human body, and
- unidirectional single impulse currents of short duration

are described.

IEC 60479-2:2019 **EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK** – Part 2: Special aspects

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

1 Scope

This part of IEC 60479 describes the effects on the human body when a sinusoidal alternating current in the frequency range above 100 Hz passes through it.

The effects of current passing through the human body for:

- alternating sinusoidal current with DC components,
- alternating sinusoidal current with phase control, and
- alternating sinusoidal current with multicycle control

are given but are only deemed applicable for alternating current frequencies from 15 Hz up to 100 Hz.

Means of extending the frequency of applicability of pure sinusoids to a frequency of 150 kHz are given, supplementing the data in IEC 60479-1.

Means of examining random complex irregular waveforms are given.

This document describes the effects of current passing through the human body in the form of single and multiple successive unidirectional rectangular impulses, sinusoidal impulses and impulses resulting from capacitor discharges.

The values specified are deemed to be applicable for impulse durations from 0,1 ms up to and including 10 ms.

This document only considers conducted current resulting from the direct application of a source of current to the body, as does IEC 60479-1. It does not consider current induced within the body caused by its exposure to an external electromagnetic field.

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. The requirements, test methods or test conditions of this basic safety publication will not apply unless specifically referred to or included in the relevant publications.

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 60479-1:2018, *Effects of current on human beings and livestock – Part 1: General aspects*

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

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

koniec náhľadu – text ďalej pokračuje v platenej verzii STN