



**SLOVENSKI STANDARD**  
**SIST-TS IEC/TS 60479-1:2006**  
**01-september-2006**

---

**Vplivi električnega toka na človeka in živali – 1. del: Splošno**

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

Effets du courant sur l'homme et les animaux domestiques - Partie 1: Aspects généraux

**Ta slovenski standard je istoveten z: IEC/TS 60479-1**

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

<https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006>

**ICS:**

13.200	Preprečevanje nesreč in katastrof	Accident and disaster control
--------	-----------------------------------	-------------------------------

**SIST-TS IEC/TS 60479-1:2006**                      **en**

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

<https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006>



IEC/TS 60479-1

Edition 4.0 2005-07

# TECHNICAL SPECIFICATION

# SPÉCIFICATION TECHNIQUE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

**Effects of current on human beings and livestock –  
Part 1: General aspects** (standards.iteh.ai)

**Effets du courant sur l'homme et les animaux domestiques –  
Partie 1: Aspects généraux**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

PRICE CODE  
CODE PRIX

**XA**

## CONTENTS

FOREWORD.....	6
INTRODUCTION.....	9
1 Scope.....	11
2 Normative references .....	12
3 Terms and definitions .....	12
3.1 General definitions .....	12
3.2 Effects of sinusoidal alternating current in the range 15 Hz to 100 Hz .....	13
3.3 Effects of direct current .....	14
4 Electrical impedance of the human body.....	14
4.1 Internal impedance of the human body ( $Z_i$ ) .....	14
4.2 Impedance of the skin ( $Z_s$ ).....	15
4.3 Total impedance of the human body ( $Z_T$ ).....	15
4.4 Factors affecting initial resistance of the human body ( $R_O$ ).....	15
4.5 Values of the total impedance of the human body ( $Z_T$ ).....	15
4.6 Value of the initial resistance of the human body ( $R_O$ ) .....	23
5 Effects of sinusoidal alternating current in the range of 15 Hz to 100 Hz.....	23
5.1 Threshold of perception.....	23
5.2 Threshold of reaction.....	23
5.3 Immobilization .....	23
5.4 Threshold of let-go .....	23
5.5 Threshold of ventricular fibrillation.....	24
5.6 Other effects related to electric shocks.....	24
5.7 Effects of current on the skin.....	25
5.8 Description of time/current zones (see Figure 20).....	26
5.9 Application of heart-current factor ( $F$ ) .....	26
6 Effects of direct current .....	27
6.1 Threshold of perception and threshold of reaction .....	27
6.2 Threshold of immobilization and threshold of let-go .....	27
6.3 Threshold of ventricular fibrillation.....	27
6.4 Other effects of current .....	28
6.5 Description of time/current zones (see Figure 22).....	29
6.6 Heart factor .....	29
Annexes .....	48
Annex A (normative) Measurements of the total body impedances $Z_T$ made on living human beings and on corpses and the statistical analysis of the results .....	49
Annex B (normative) Influence of frequency on the total body impedance ( $Z_T$ ) .....	52
Annex C (normative) Total body resistance ( $R_T$ ) for direct current .....	53
Annex D (informative) Examples of calculations of $Z_T$ .....	54
Bibliography.....	58

Figure 1 – Impedances of the human body.....	29
Figure 2 – Internal partial impedances $Z_{ip}$ of the human body .....	30
Figure 3 – Simplified schematic diagram for the internal impedances of the human body .....	31
Figure 4 – Total body impedances $Z_T$ (50 %) for a current path hand to hand, for large surface areas of contact in dry, water-wet and saltwater-wet conditions for a percentile rank of 50 % of the population for touch voltages $U_T = 25$ V to 700 V, a.c. 50/60 Hz.....	32
Figure 5 – Dependence of the total impedance $Z_T$ of one living person on the surface area of contact in dry condition and at touch voltage (50 Hz) .....	33
Figure 6 – Dependence of the total body impedance $Z_T$ on the touch voltage $U_T$ for a current path from the tips of the right to the left forefinger compared with large surface areas of contact from the right to the left hand in dry conditions measured on one living person, touch voltage range $U_T = 25$ V to 200 V, a.c. 50 Hz, duration of current flow max. 25 ms .....	34
Figure 7 – Dependence of the total body impedance $Z_T$ for the 50 <sup>th</sup> percentile rank of a population of living human beings for large, medium and small surface areas of contact (order of magnitude 10 000 mm <sup>2</sup> , 1 000 mm <sup>2</sup> and 100 mm <sup>2</sup> respectively) in dry conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz.....	35
Figure 8 – Dependence of the total body impedance $Z_T$ for the 50 <sup>th</sup> percentile rank of a population of living human beings for large, medium and small surface areas of contact (order of magnitude 10 000 mm <sup>2</sup> , 1 000 mm <sup>2</sup> and 100 mm <sup>2</sup> respectively) in water-wet conditions at touch voltages $U_T = 25$ V to 200 V, a.c. 50/60 Hz.....	36
Figure 9 – Dependence of the total body impedance $Z_T$ for the 50 <sup>th</sup> percentile rank of a population of living human beings for large, medium and small surface areas of contact (order of magnitude 10 000 mm <sup>2</sup> , 1 000 mm <sup>2</sup> and 100 mm <sup>2</sup> respectively) in saltwater-wet conditions at touch voltages $U_T = 25$ V to 200 V, a.c. 50/60 Hz .....	37
Figure 10 – Values for the total body impedance $Z_T$ measured on 10 living human beings with a current path hand to hand and large surface areas of contact in dry conditions at a touch voltage of 10 V and frequencies from 25 Hz to 20 kHz .....	38
Figure 11 – Values for the total body impedance $Z_T$ measured on one living human being with a current path hand to hand and large surface areas of contact in dry conditions at a touch voltage of 25 V and frequencies from 25 Hz to 2 kHz .....	38
Figure 12 – Frequency dependence of the total body impedance $Z_T$ of a population for a percentile rank of 50 % for touch voltages from 10 V to 1 000 V and a frequency range from 50 Hz to 2 kHz for a current path hand to hand or hand to foot, large surface areas of contact in dry conditions .....	39
Figure 13 – Statistical value of total body impedances $Z_T$ and body resistances $R_T$ for a percentile rank of 50 % of a population of living human beings for the current path hand to hand, large surface areas of contact, dry conditions, for touch voltages up to 700 V, for a.c. 50/60 Hz and d.c.....	40
Figure 14 – Dependence of the alteration of human skin condition on current density $i_T$ and duration of current flow (for detailed description of zones, see 5.7) .....	41
Figure 15 – Electrodes used for the measurement of the dependence of the impedance of the human body $Z_T$ on the surface area of contact .....	42

Figure 16 – 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 conditions taken from measurements .....	43
Figure 17 – Occurrence of the vulnerable period of ventricles during the cardiac cycle .....	44
Figure 18 – Triggering of ventricular fibrillation in the vulnerable period – Effects on electro-cardiogram (ECG) and blood pressure .....	44
Figure 19 – Fibrillation data for dogs, pigs and sheep 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 and 380 V a.c. with body impedances $Z_T$ (5 %) .....	45
Figure 20 – Conventional time/current zones of effects of a.c. currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet (for explanation see Table 11).....	46
Figure 21 – Oscillogram of touch voltages $U_T$ and touch current $I_T$ for d.c., current path hand to hand, large surface areas of contact in dry conditions .....	46
Figure 22 – Conventional time/current zones of effects of d.c. currents on persons for a longitudinal upward current path (for explanation see Table 13).....	47
Figure 23 – Let-go currents for 60 Hz sinusoidal current.....	47
Table 1 – Total body impedances $Z_T$ for a current path hand to hand a.c. 50/60 Hz, for large surface areas of contact in dry conditions .....	16
Table 2 – Total body impedances $Z_T$ for a current path hand to hand a.c. 50/60 Hz, for large surface areas of contact in water-wet conditions .....	17
Table 3 – Total body impedances $Z_T$ for a current path hand to hand a.c. 50/60 Hz, for large surface areas of contact in saltwater-wet conditions.....	18
Table 4 – Total body impedances $Z_T$ for a current path hand to hand for medium surface areas of contact in dry conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 25 $\Omega$ ) .....	19
Table 5 – Total body impedances $Z_T$ for a current path hand to hand for medium surface areas of contact in water-wet conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 25 $\Omega$ ).....	20
Table 6 – Total body impedances $Z_T$ for a current path hand to hand for medium surface areas of contact in saltwater-wet conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 5 $\Omega$ ).....	20
Table 7 – Total body impedances $Z_T$ for a current path hand to hand for small surface areas of contact in dry conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 25 $\Omega$ ) .....	20
Table 8 – Total body impedances $Z_T$ for a current path hand to hand for small surface areas of contact in water-wet conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 25 $\Omega$ ) .....	21

Table 9 – Total body impedances $Z_T$ for a current path hand to hand for small surface areas of contact in saltwater-wet conditions at touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz (values rounded to 5 $\Omega$ ) .....	21
Table 10 – Total body resistances $R_T$ for a current path hand to hand, d.c., for large surface areas of contact in dry conditions .....	22
Table 11 – Time/current zones for a.c. 15 Hz to 100 Hz for hand to feet pathway : Summary of zones of Figure 20 .....	26
Table 12 – Heart-current factor $F$ for different current paths.....	27
Table 13 – Time/current zones for d.c. for hand to feet pathway – Summary of zones of Figure 22 .....	29
Table A.1 – Total body impedances $Z_T$ , electrodes type A for dry condition and deviation factors $F_D$ (5 % and 95 %) .....	49
Table A.2 – Total body impedances $Z_T$ , electrodes type B for dry, water-wet and saltwater-wet conditions and deviation factors $F_D$ (5 % and 95 %) .....	49
Table A.3 – Total body impedances $Z_T$ for dry, water-wet and saltwater-wet conditions and deviation factors $F_D$ (5 % and 95 %). .....	50
Table A.4 – Deviation factors $F_D$ (5 %) and $F_D$ (95 %) for dry and water-wet conditions in the touch voltage range $U_T = 25$ V up to 400 V for large, medium and small surface areas of contact.....	51
Table D.1 – 50 <sup>th</sup> percentile values for the total body impedance for a current path hands-feet medium surface area of contact for hands, large for feet, reduction factor 0,8, dry conditions, touch currents $I_T$ and electrophysiological effects.....	56

(standards.iteh.ai)

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

<https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006>

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## 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.
- 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. 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 50<sup>th</sup> 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 the main 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.

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

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

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 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

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

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

## **iTeh STANDARD PREVIEW** **(standards.iteh.ai)**

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

<https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006>

## INTRODUCTION

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 specification, it must 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 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 be considered carefully when fixing safety requirements, for example, operating characteristics of protective devices for electrical installations.

The form of the specification 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 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 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 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.

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<sup>2</sup>) in dry, water-wet and saltwater-wet conditions and with medium and small surface areas of contact (order of magnitude 1 000 mm<sup>2</sup> and 100 mm<sup>2</sup>) 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<sup>2</sup> and 1 mm<sup>2</sup>) 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.

(standards.iteh.ai)

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.

## 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.

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-3011e2000000/iec-60479-1-2006)

[https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-3011e2000000/iec-60479-1-2006)

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*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

### 3.1 General definitions

#### 3.1.1

##### **longitudinal current**

current flowing lengthwise through the trunk of the human body such as from hand to feet

#### 3.1.2

##### **transverse current**

current flowing across the trunk of the human body such as from hand to hand

#### 3.1.3

##### **internal impedance of the human body**

$Z_i$

impedance between two electrodes in contact with two parts of the human body, neglecting skin impedances

#### 3.1.4

##### **impedance of the skin**

$Z_s$

impedance between an electrode on the skin and the conductive tissues underneath

#### 3.1.5

##### **total impedance of the human body**

$Z_T$

vectorial sum of the internal impedance and the impedances of the skin (see Figure 1)

#### 3.1.6

##### **initial resistance of the human body**

$R_0$

resistance limiting the peak value of the current at the moment when the touch voltage occurs

#### 3.1.7

##### **dry condition**

condition of the skin of a surface area of contact with regard to humidity of a living person being at rest under normal indoor environmental conditions

**3.1.8****water-wet condition**

condition of the skin of a surface area of contact being exposed for 1min to water of public water supplies (average resistivity  $\rho = 3\,500\ \Omega\text{cm}$ , pH = 7 to 9)

**3.1.9****saltwater-wet condition**

condition of the skin of a surface area of contact being exposed for 1 min to a 3 % solution of NaCl in water (average resistivity  $\rho = 30\ \Omega\text{cm}$ , pH = 7 to 9)

NOTE It is assumed that saltwater-wet condition simulates the condition of the skin of a sweating person or a person after immersion in seawater. Further investigations are necessary.

**3.1.10****deviation factor**

$F_D$

total body impedance  $Z_T$  for a given percentile rank of a population divided by the total body impedance  $Z_T$  for a percentile rank of 50 % of a population at a given touch voltage

$$F_D (X\%, U_T) = \frac{Z_T (X\%, U_T)}{Z_T (50\%, U_T)}$$

**3.2 Effects of sinusoidal alternating current in the range 15 Hz to 100 Hz****3.2.1****threshold of perception**

minimum value of touch current which causes any sensation for the person through which it is flowing

[SIST-TS IEC/TS 60479-1:2006](https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006)

<https://standards.iteh.ai/catalog/standards/sist/74fc8bec-b5a3-438f-8093-b5259d91ce85/sist-ts-iec-ts-60479-1-2006>

**3.2.2****threshold of reaction**

minimum value of touch current which causes involuntary muscular contraction

**3.2.3****threshold of let-go**

maximum value of touch current at which a person holding electrodes can let go of the electrodes

**3.2.4****threshold of ventricular fibrillation**

minimum value of touch current through the body which causes ventricular fibrillation

**3.2.5****heart-current factor**

$F$

relates the electric field strength (current density) in the heart for a given current path to the electric field strength (current density) in the heart for a touch current of equal magnitude flowing from left hand to feet

NOTE In the heart, the current density is proportional to the electric field strength.

**3.2.6****vulnerable period**

comparatively small part of the cardiac cycle during which the heart fibres are in an inhomogeneous state of excitability and ventricular fibrillation occurs if they are excited by an electric current of sufficient magnitude

NOTE The vulnerable period corresponds to the first part of the T-wave in the electrocardiogram which is approximately 10 % of the cardiac cycle (see Figures 17 and 18).