

Effects of current on human beings and livestock —

Part 1: General aspects

ICS 13.200; 29.020

National foreword

This Published Document is the UK implementation of IEC/TS 60479-1:2005+A1:2016, incorporating corrigenda October 2006 and June 2013. It supersedes DD IEC/TS 60479-1:2005 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC/TS text carry the number of the IEC/TS amendment. For example, text altered by IEC/TS amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee JPEL/64, Electrical installations of buildings.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 12 January 2006

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ISBN 978 0 580 90939 9

Amendments/corrigenda issued since publication

Amd. No.	Date	Comments
17146 Corrigendum No. 1	29 June 2007	Implementation of IEC corrigendum October 2006: Figures 22 and 23 replaced.
	30 September 2013	Implementation of IEC corrigendum June 2013: Figure 2 replaced
	31 August 2016	Implementation of IEC/TS amendment 1:2016. Document identifier updated



TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

**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**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XA

ICS 13.200; 29.020

ISBN 2-8318-8096-3

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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.
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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 $U_T = 25 \text{ V}$ to $200 \text{ V a.c. 50/60 Hz}$.
- 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 $U_T = 220 \text{ V}$ 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.
- A1 – 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. A1

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

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 and June 2013 have been included in this copy.

INTRODUCTION

A1 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. **A1**

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*

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

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).

3.3 Effects of direct current

3.3.1

total body resistance

R_T

sum of the internal resistance of the human body and the resistances of the skin

3.3.2

d.c./a.c. equivalence factor

k

ratio of direct current to its equivalent r.m.s. value of alternating current having the same probability of inducing ventricular fibrillation

NOTE As an example for shock durations longer than the period of one cardiac cycle and 50 % probability for ventricular fibrillation, the equivalence factor for 10 s is approximately:

$$k = \frac{I_{\text{d.c.-fibrillation}}}{I_{\text{a.c.-fibrillation (r.m.s.)}}} = \frac{300 \text{ mA}}{80 \text{ mA}} = 3,75 \text{ (see Figures 20 and 22)}$$

3.3.3

upward current

direct touch current through the human body for which the feet represent the positive polarity

3.3.4

downward current

direct touch current through the human body for which the feet represent the negative polarity

4 Electrical impedance of the human body

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.

A schematic diagram for the impedance of the human body is shown in Figure 1.

4.1 Internal impedance of the human body (Z_i)

The internal impedance of the human body can be considered as mostly resistive. Its value depends primarily on the current path and, to a lesser extent, on the surface area of contact.

NOTE 1 Measurements indicate that a small capacitive component exists (dashed lines in Figure 1).

Figure 2 shows the internal impedance of the human body for its different parts expressed as percentages of that related to the path hand to foot.

For current paths hand to hand or hand to feet, the impedances are mainly located in the limbs (arms and legs). If the impedance of the trunk of the body is neglected, a simplified circuit diagram can be established which is shown in Figure 3.

NOTE 2 In order to simplify the circuit diagram, it is assumed that the impedance of arms and legs have the same values.

4.2 Impedance of the skin (Z_S)

The impedance of the skin can be considered as a network of resistances and capacitances. Its structure is made up of a semi-insulating layer and small conductive elements (pores). The skin impedance falls when the current is increased. Sometimes current marks are observed (see 4.7).

The value of the impedance of the skin depends on voltage, frequency, duration of the current flow, surface area of contact, pressure of contact, the degree of moisture of the skin, temperature and type of the skin.

For lower touch voltages the value of the impedance of the skin varies widely, even for one person, with surface area of contact and condition (dry, wet, perspiration), temperature, rapid respiration, etc. For higher touch voltages the skin impedance decreases considerably and becomes negligible when the skin breaks down.

As regards the influence of frequency, the impedance of the skin decreases when the frequency increases.

4.3 Total impedance of the human body (Z_T)

The total impedance of the human body consists of resistive and capacitive components.

For lower touch voltages, there are considerable variations in the impedance of the skin Z_S and the total impedance of the human body Z_T similarly varies widely. For higher touch voltages, the total impedance depends less and less on the impedance of the skin and its value approaches that of the internal impedance Z_i . See Figures 4 to 9.

As regards the influence of frequency, taking into account the frequency dependence of the skin impedance, the total impedance of the human body is higher for direct current and decreases when the frequency increases.

4.4 Factors affecting initial resistance of the human body (R_0)

At the moment when the touch voltage occurs, capacitances in the human body are not charged. Therefore skin impedances Z_{S1} and Z_{S2} are negligible and the initial resistance R_0 is approximately equal to the internal impedance of the human body Z_i (see Figure 1). The initial resistance R_0 depends mainly on the current path and to a lesser extent on the surface area of contact.

The initial resistance R_0 limits the current peaks of short impulses (e.g. shocks from electric fence controllers).

4.5 Values of the total impedance of the human body (Z_T)

The dependence of the total body impedance Z_T for the 50th percentile rank of a population of living human beings for large, medium and small surface areas of contact (order of magnitude 10 000 mm², 1 000 mm² and 100 mm² respectively) in dry, water-wet and saltwater-wet conditions at touch voltages $U_T = 25$ V a.c. to 200 V a.c. is shown in Figures 7, 8 and 9.

4.5.1 Sinusoidal alternating current 50/60 Hz for large surface areas of contact

The values of the total body impedances in Tables 1, 2 and 3 are valid for living human beings and a current path hand to hand for large surface areas of contact (order of magnitude 10 000 mm²) in dry (Table 1), water-wet (Table 2) and saltwater-wet (Table 3) conditions.

The range of the total body impedances for touch voltages up to 700 V for large surface areas of contact in dry, water-wet and saltwater-wet conditions for a percentile rank of 50 % of the population is presented in Figure 4.

The values for Tables 1, 2 and 3 represent the best knowledge on the total body impedances Z_T for living adults. On the knowledge at present available the total body impedance Z_T for children is expected to be somewhat higher but of the same order of magnitude.

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

Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	1 750	3 250	6 100
50	1 375	2 500	4 600
75	1 125	2 000	3 600
100	990	1 725	3 125
125	900	1 550	2 675
150	850	1 400	2 350
175	825	1 325	2 175
200	800	1 275	2 050
225	775	1 225	1 900
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value = internal impedance	575	775	1 050

NOTE 1 Some measurements indicate that the total body impedance for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %).

NOTE 2 For living persons the values of Z_T correspond to a duration of current flow of about 0,1 s. For longer durations Z_T values may decrease (about 10 % to 20 %) and after complete rupture of the skin Z_T approaches the internal body impedance Z_i .

NOTE 3 For the standard value of the voltage 230 V (network-system 3N ~ 230/400 V) it may be assumed that the values of the total body impedance are the same as for a touch voltage of 225 V.

NOTE 4 Values of Z_T are rounded to 25 Ω .

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

Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	1175	2 175	4 100
50	1100	2 000	3 675
75	1025	1 825	3 275
100	975	1 675	2 950
125	900	1 550	2 675
150	850	1 400	2 350
175	825	1 325	2 175
200	800	1 275	2 050
225	775	1 225	1 900
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value =internal impedance	575	775	1 050

NOTE 1 Some measurements indicate that the total body impedance for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %).

NOTE 2 For living persons the values of Z_T correspond to a duration of current flow of about 0,1 s. For longer durations Z_T values may decrease (about 10 % to 20 %) and after complete rupture of the skin Z_T approaches the internal body impedance Z_i .

NOTE 3 For the standard value of the voltage 230 V (network-system 3N ~ 230/400 V) it may be assumed that the values of the total body impedance are the same as for a touch voltage of 225 V.

NOTE 4 Values of Z_T are rounded to 25 Ω .

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

Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	960	1 300	1 755
50	940	1 275	1 720
75	920	1 250	1 685
100	880	1 225	1 655
125	850	1 200	1 620
150	830	1 180	1 590
175	810	1 155	1 560
200	790	1 135	1 530
225	770	1 115	1 505
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value = internal impedance	575	775	1 050

NOTE 1 Some measurements indicate that the total body impedance for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %).

NOTE 2 Due to low skin impedances in this case it may be assumed that Z_T depends little on the duration of current flow; Z_T approaches the internal body impedance Z_i .

NOTE 3 For the standard value of the voltage 230 V (network-system 3N ~ 230/400 V) it may be assumed that the values of the total body impedance are the same as for a touch voltage of 225 V.

NOTE 4 Values of Z_T are rounded to 5 Ω .

The values indicated in Tables 1 to 3 have been derived from measurements carried out on corpses and on living persons (adults, males and females) as described in Annex A.

At voltages higher than approximately 125 V for water-wet conditions and 400 V for saltwater-wet conditions the values for the total body impedance are the same as for dry conditions (see Figure 4).

4.5.2 Sinusoidal alternating current 50/60 Hz for medium and small surface areas of contact

The value of the internal body impedances Z_i and of the initial body resistance R_0 (see 4.6) depend only to a small extent on the surface areas of contact.

However, when the surface area of contact is very small, in the order of a few square millimetres, the values are increased.

After the skin has broken down (for touch voltages over approx. 100 V and after longer durations of current flow), the total body impedance Z_T approaches values of the internal body impedance Z_i and depends only to a small extent on the surface area of contact and its condition of dampness.

The measurements of the dependence of the total body impedance Z_T on the surface area of contact for a.c. 50 Hz in dry, water-wet and saltwater-wet conditions which have been carried out on living persons at touch voltages of $U_T = 25$ V to 200 V are described in Annex A.

NOTE No data on Z_T for surface areas in water-wet and saltwater-wet conditions of persons or corpses is available for touch voltages above 200 V.

The dependence of the total body impedance Z_T for a current path hand to hand on the surface area of contact (from 1 mm² up to approximately 8 000 mm²) in dry condition for a touch voltage range of 25 V to 200 V, a.c. 50 Hz, measured on one person is shown in Figure 5. For touch voltages below 100 V and small surface areas of contact in the order of a few mm², deviations in the measurements can easily reach about + 50 % of the average, depending on temperature, pressure, location within the palm of the hand, etc.

The dependence of the total body impedance Z_T between the tips of the right forefinger and the left forefinger (surface area of contact approximately 250 mm²) on the touch voltage for a.c. 50/60 Hz for a voltage range from 25 V to 200 V is shown in Figure 6.

From Figure 6 one can calculate that the partial impedance of one forefinger at a touch voltage of 200 V is on the order of 1 000 Ω .

The measurements of the total body impedance Z_T shown in Figures 5 and 6 have been carried out on one living person only.

For a percentile rank of 5 %, 50 % and 95 % of a population of living human beings on the knowledge at present available the following presentation is given for the total body impedance Z_T for large, medium and small surface areas of contact (order of magnitude 10 000 mm², 1 000 mm² and 100 mm² respectively) in dry, water-wet and saltwater-wet conditions:

- for large surface areas of contact, the values have been presented in Tables 1, 2 and 3 for dry, water-wet and saltwater-wet conditions for touch voltages $U_T = 25$ V to 1 000 V, a.c. 50/60 Hz;
- for medium surface areas of contact, the values are presented in the following Tables 4, 5 and 6 for dry, water-wet and saltwater-wet conditions for touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz;
- for small surface areas of contact, the values are presented in the following Tables 7, 8 and 9 for dry, water-wet and saltwater-wet conditions for touch voltages $U_T = 25$ V to 200 V a.c. 50/60 Hz.

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 Ω)

Touch voltage V	Values for the total body impedances Z_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	11 125	20 600	38 725
50	7 150	13 000	23 925
75	4 625	8 200	14 750
100	3 000	5 200	9 150
125	2 350	4 000	6 875
150	1 800	3 000	5 050
175	1 550	2 500	4 125
200	1 375	2 200	3 525

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 $U_T = 25 \text{ V}$ to 200 V a.c. 50/60 Hz (values rounded to 25Ω)

Touch voltage V	Values for the total body impedances $Z_T (\Omega)$ that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	5 050	9 350	17 575
50	4 100	7 450	13 700
75	3 400	6 000	10 800
100	2 800	4 850	8 525
125	2 350	4 000	6 875
150	1 800	3 000	5 050
175	1 550	2 500	4 125
200	1 375	2 200	3 525

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 $U_T = 25 \text{ V}$ to 200 V a.c. 50/60 Hz (values rounded to 5Ω)

Touch voltage V	Values for the total body impedances $Z_T (\Omega)$ that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	1 795	2 425	3 275
50	1 765	2 390	3 225
75	1 740	2 350	3 175
100	1 715	2 315	3 125
125	1 685	2 280	3 075
150	1 660	2 245	3 030
175	1 525	2 210	2 985
200	1 350	2 175	2 935

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 $U_T = 25 \text{ V}$ to 200 V a.c. 50/60 Hz (values rounded to 25Ω)

Touch voltage V	Values for the total body impedances $Z_T (\Omega)$ that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	91 250	169 000	317 725
50	74 800	136 000	250 250
75	42 550	74 000	133 200
100	23 000	40 000	70 400
125	12 875	22 000	37 850
150	7 200	12 000	20 225
175	4 000	6 500	10 725
200	3 500	5 400	8 650