

TECHNICAL SPECIFICATION



BASIC SAFETY PUBLICATION

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

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CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	8
4 Effects of alternating currents with frequencies above 100 Hz	10
4.1 General.....	10
4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz	11
4.2.1 Threshold of perception	11
4.2.2 Threshold of let-go	11
4.2.3 Threshold of ventricular fibrillation	12
4.3 Effects of alternating current in the frequency range above 1 000 Hz up to and including 10 000 Hz.....	13
4.3.1 Threshold of perception	13
4.3.2 Threshold of let-go	13
4.3.3 Threshold of ventricular fibrillation	14
4.4 Effects of alternating current in the frequency range above 10 000 Hz	14
4.4.1 General	14
4.4.2 Threshold of perception	14
4.4.3 Threshold of let-go	14
4.4.4 Threshold of ventricular fibrillation	14
4.4.5 Other effects.....	15
5 Effects of special waveforms of current	15
5.1 General.....	15
5.2 Equivalent magnitude, frequency and threshold	16
5.3 Effects of alternating current with DC components	16
5.3.1 Waveforms and frequencies and current thresholds.....	16
5.3.2 Threshold of startle reaction	17
5.3.3 Threshold of let-go	18
5.3.4 Threshold of ventricular fibrillation	19
6 Effects of alternating current with phase control	22
6.1 Waveforms and frequencies and current thresholds	22
6.2 Threshold of startle reaction and threshold of let-go.....	23
6.3 Threshold of ventricular fibrillation	24
6.3.1 General	24
6.3.2 Symmetrical control	24
6.3.3 Asymmetrical control	24
7 Effects of alternating current with multicyle control	24
7.1 Waveforms and frequencies.....	24
7.2 Threshold of startle reaction and threshold of let-go.....	25
7.3 Threshold of ventricular fibrillation	25
7.3.1 General	25
7.3.2 Shock durations exceeding longer than 1,5 times the period of the cardiac cycle	26
7.3.3 Shock durations less than 0,75 times the period of the cardiac cycle	26
8 Estimation of the equivalent current threshold for mixed frequencies	26

8.1	Threshold of perception and let-go.....	26
8.2	Threshold of ventricular fibrillation	27
9	The effect of repeated pulses (bursts) of current on the threshold of ventricular fibrillation Effects of current pulse bursts and random complex irregular waveforms	27
9.1	Ventricular fibrillation threshold of multiple bursts pulses of current separated by 1 s 300 ms or more	27
9.2	Ventricular fibrillation threshold of multiple bursts pulses of current separated by less than 1 s 300 ms	27
9.2.1	General	27
9.2.2	Examples.....	28
9.2.3	Random complex irregular waveforms	31
10	Effects of electric current through the immersed human body	33
10.1	General.....	33
10.2	Resistivity of water solutions and of the human body	33
10.3	Conducted current through immersed body	35
10.4	Physiological effects of current through the immersed body	36
10.5	Threshold values of current.....	37
10.6	Intrinsically “safe” voltage values	37
11	Effects of unidirectional single impulse currents of short duration	37
11.1	General.....	37
11.2	Effects of unidirectional impulse currents of short duration.....	38
11.2.1	Waveforms	38
11.2.2	Determination of specific fibrillating energy F_e	39
11.3	Threshold of perception and threshold of pain for capacitor discharge	40
11.4	Threshold of ventricular fibrillation.....	41
11.4.1	General.....	41
11.4.2	Examples.....	43
	Annex A (informative) Random complex irregular waveform analysis	45
A.1	General.....	45
A.2	Formal theoretical statement of the method	45
A.3	Demonstration of the calculation	46
A.3.1	General	46
A.3.2	Choice of justified current.....	48
A.3.3	Choice of sampling step size	48
A.4	Examples 1 and 2	49
	Bibliography.....	52
	Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz	11
	Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz.....	12
	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	12
	Figure 4 – Variation of the threshold of perception within the frequency range 1 000 Hz to 10 000 Hz	13
	Figure 5 – Variation of the threshold of let-go within the frequency range 1 000 Hz to 10 000 Hz.....	13

Figure 6 – Variation of the threshold of ventricular fibrillation for continuous sinusoidal current for use from 1 000 Hz to a maximum of 150 kHz	15
Figure 7 – Waveforms of currents	17
Figure 8 – Let-go thresholds for men, women and children	18
Figure 9 – 99,5 percentile let-go threshold for combinations of 50/60 Hz sinusoidal alternating current and direct current	19
Figure 10 – Composite alternating and direct current with equivalent likelihood of ventricular fibrillation.....	20
Figure 11 – Waveforms of rectified alternating currents	21
Figure 12 – Waveforms of alternating currents with phase control.....	23
Figure 13 – Waveforms of alternating currents with multicycle control.....	25
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).....	26
Figure 15 – Series of four rectangular pulses of unidirectional current.....	29
Figure 16 – Series of four rectangular pulses of unidirectional current.....	29
Figure 17 – Series of four rectangular pulses of unidirectional current.....	30
Figure 18 – Example of current versus elapsed time over a contaminated insulator	32
Figure 19 – PC plotted on the AC time current curves (Figure 20 of IEC TS 60479-1:2005)	33
Figure 20 – Forms of current for rectangular impulses, sinusoidal impulses and for capacitor discharges	39
Figure 21 – Rectangular impulse, sinusoidal impulse and capacitor discharge having the same specific fibrillating energy and the same shock-duration	40
Figure 22 – Threshold of perception and threshold of pain for the current resulting from the discharge of a capacitor (dry hands, large contact area)	41
Figure 23 – Threshold of ventricular fibrillation Probability of fibrillation risks for current flowing in the path left hand to feet	42
Figure A.1 – Definition of a segment of a random complex waveform.....	45
Figure A.2 – Definition of a duration within a sample.....	45
Figure A.3 – PC for demonstration example of the random complex waveform method plotted against time-current curves for RMS AC	48
Figure A.4 – Random complex waveform typical of those used in Example 1	49
Figure A.5 – Random complex waveform typical of those used in Example 2	50
Figure A.6 – PC for Examples 1 and 2 of the random complex waveform method plotted against time-current curves for RMS AC.....	51
Table 1 – Example of estimate for ventricular fibrillation threshold after each burst of current in a series of pulses each of which excited the heart tissue.....	28
Table 2 – Resistivity of water solutions [24], [25]	34
Table 3 – Resistivity of human body tissues.....	35
Table 4 – Relative interaction between the resistivity of water solution and the impedance characteristic of the electrical source	36
Table 5 – Effects of shocks.....	43
Table 6 – Effects of shocks.....	44

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 2: Special aspects

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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 TS 60479-2, 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 in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Changes reflecting the change in applicability of frequency from 1 kHz to 150 kHz have been added.
- The examination of random complex irregular waveforms has been added.
- The handling of successive DC pulses has been clarified.

The text of this Technical Specification is based on the following documents:

Draft TS	Report on voting
64/2143/DTS	64/2166/RVDTS

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

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 publication will remain unchanged until the stability date indicated on the IEC website 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.

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EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 2: Special aspects

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;
- alternating sinusoidal current with multicycle control

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

~~NOTE 1 – Other waveforms are under consideration.~~

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

~~NOTE 2 – The effects of sequences of impulses are under consideration.~~

The values specified are deemed to be applicable for impulse durations from 0,1 ms up to and including 10 ms. ~~For impulse durations greater than 10 ms, the values given in Figure 20 of IEC 60479-1 apply.~~

This document only considers conducted current resulting from the direct application of a source of current to the body, as does IEC TS 60479-1 and IEC TS 60479-3. 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 TS 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TS 60479-1:2005/AMD1:2016

~~IEC 60479-3, *Effects of current on human beings and livestock – Part 3: Effects of currents passing through the body of livestock*~~

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

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

IEC Guide 104, *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 terms and definitions given in IEC TS 60479-1 and the following apply.

~~NOTE Certain definitions are taken from the IECV. Such references are listed in the bibliography [27], [28].~~

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 frequency factor

F_f
ratio of the threshold current for the relevant physiological effects at the frequency f to the threshold current at 50/60 Hz

Note 1 to entry The frequency factor differs for perception, let-go and ventricular fibrillation.

3.2 phase control

process of varying the instant within the cycle at which current conduction in an electronic valve device or a valve arm begins

[SOURCE: IEC 60050-551:1998, 551-16-23]

3.3 phase control angle current delay angle

time expressed in angular measure by which the starting instant of current conduction is delayed by phase control

[SOURCE: IEC 60050-551:1998, 551-16-32, modified — the term "phase control angle" has been added.]

3.4 multicycle control

process of varying the ratio of the number of cycles which include current conduction to the number of cycles in which no current conduction occurs

[SOURCE: IEC 60050-551:1998, 551-16-31]

3.5 multicycle control factor

p
ratio between the number of conducting cycles and the sum of conducting and non-conducting cycles in the case of multicycle control

SEE Figure 13.

[SOURCE: IEC 60050-551:1998, 551-16-37, modified — the symbol and reference to Figure 13 have been added.]

3.6 specific fibrillating energy

F_e
minimum $I^2 \cdot t$ value of a unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

Note 1 to entry: F_e is determined by the form of the impulse as the integral

$$\int_0^{t_i} i^2 dt$$

where t_i is defined in Figure 20 and Figure 21. F_e multiplied by the body resistance gives the energy dissipated in the human body during the impulse.

Note 2 to entry: F_e is expressed in Ws/Ω or A^2s .

3.7 specific fibrillating charge

F_q
minimum $I \cdot t$ value of unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

Note 1 to entry: F_q is determined by the form of the impulse as the integral

$$\int_0^{t_i} i dt$$

where t_i is defined in Figure 20 and Figure 21.

Note 2 to entry: F_q is expressed in C or As.

3.8 time constant

time required for the amplitude of an exponentially decaying quantity to decrease to

$$\frac{1}{e} = 0,3679$$

times an initial amplitude

[SOURCE: IEC 60050-801:1994, 801-21-45, modified — the definition has been revised.]

3.9 shock-duration of a capacitor discharge

t_i
time interval from the beginning of the discharge to the time when the discharge current has fallen to 5 % of its peak value

Note 1 to entry: When the time constant of the capacitor discharge is given by T the shock-duration of the capacitor discharge is equal to $3T$. During the shock-duration of the capacitor discharge practically all the energy of the impulse is dissipated.

Note 2 to entry: See Figure 20 and Figure 21.

3.10 shock-duration for complex asymptotic waveform

t_i
shortest duration of that part of the impulse that contains 95 % of the energy over the total impulse

3.11 threshold of perception

minimum value for the charge of electricity which under given conditions causes any sensation to the person through whom it is flowing

3.12 threshold of pain

minimum value for the charge ($I \cdot t$) or specific energy ($I^2 \cdot t$) that can be applied as an impulse to a person holding a large electrode in the hand without causing pain

3.13 pain

unpleasant experience such that it is not readily accepted a second time by the subject submitted to it

NOTE EXAMPLE: Electric shock above the threshold of pain described in 11.3, the sting of a bee or burn of a cigarette.

4 Effects of alternating currents with frequencies above 100 Hz

NOTE Values for 50/60 Hz are given in IEC TS 60479-1. For frequencies up to 100 Hz the provisions of IEC TS 60479-1 are used.

4.1 General

Electric energy in the form of alternating current at frequencies higher than 50/60 Hz is increasingly used in modern electrical equipment, for example aircraft (400 Hz), power tools and electric welding (mostly up to 450 Hz), electrotherapy (using mostly 4 000 Hz to 5 000 Hz) and switching mode power supplies (20 kHz to 1 MHz).

Little experimental data is available for Clause 4, therefore the information given herein should be considered as provisional only but may be used for the evaluation of risks in the frequency ranges concerned (see Bibliography).

Recent experiments in governmental funded projects are ongoing to exploit and investigate the effects of higher frequencies using the latest technologies and methods to justify existing extrapolation of the frequency factor for ventricular fibrillation (VF) threshold.

Attention is also drawn to the fact that the impedance of human skin decreases approximately inversely proportional to the frequency for touch voltages in the order of some tens of volts, so that the skin impedance at 500 Hz is only about one-tenth of the skin impedance at 50 Hz and may be neglected in many cases. This impedance of the human

body at such frequencies is therefore reduced to its internal impedance Z_i (see IEC TS 60479-1).

NOTE Use of peak measurements: at current levels that produce physiological responses of perception, startle reaction and inability of let-go, the physiological response from non sinusoidal and mixed frequency periodic current is best indicated by the peak value of an output signal from measuring circuits containing a frequency-weighting network such as those described in IEC 60990.

These frequency weighting networks attenuate the signal according to the frequency factors given in IEC TS 60479-1:2005 and IEC TS 60479-1:2005/AMD1:2016, Clause 4 so that the output signal corresponds to a constant level of physiological response. Attenuation is provided for narrow impulses of current that would produce less physiological response because of the short duration of their peak value. The network output allows a fixed value to be read independent of waveshape or mix of frequencies to be provided for ease of determination of the leakage current and evaluation of the level of hazard present.

Comparable physiological effects are produced by non sinusoidal and sinusoidal current producing the same peak value by this measurement method.

Representative network can be found in IEC 60990 and in bibliographic reference [16]¹.

4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz

4.2.1 Threshold of perception

For the threshold of perception the frequency factor is given in Figure 1.

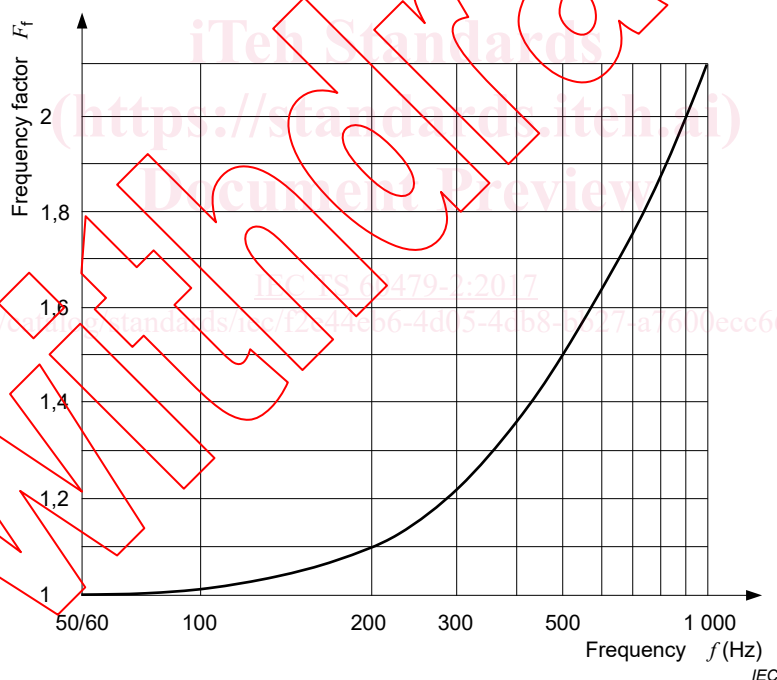


Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz

4.2.2 Threshold of let-go

For the threshold of let-go the frequency factor is given in Figure 2.

¹ Numbers in square brackets refer to the Bibliography.

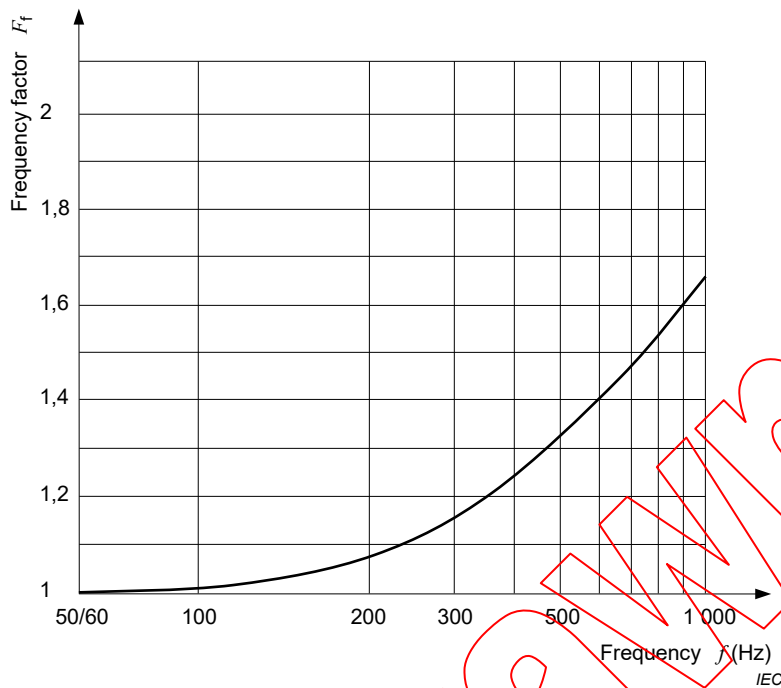


Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz

4.2.3 Threshold of ventricular fibrillation

For shock durations longer than the cardiac cycle, the frequency factor for the threshold of fibrillation for longitudinal current paths through the trunk of the body is given in Figure 3.

For shock durations shorter than the cardiac cycle no experimental data is available on the effects of frequency.

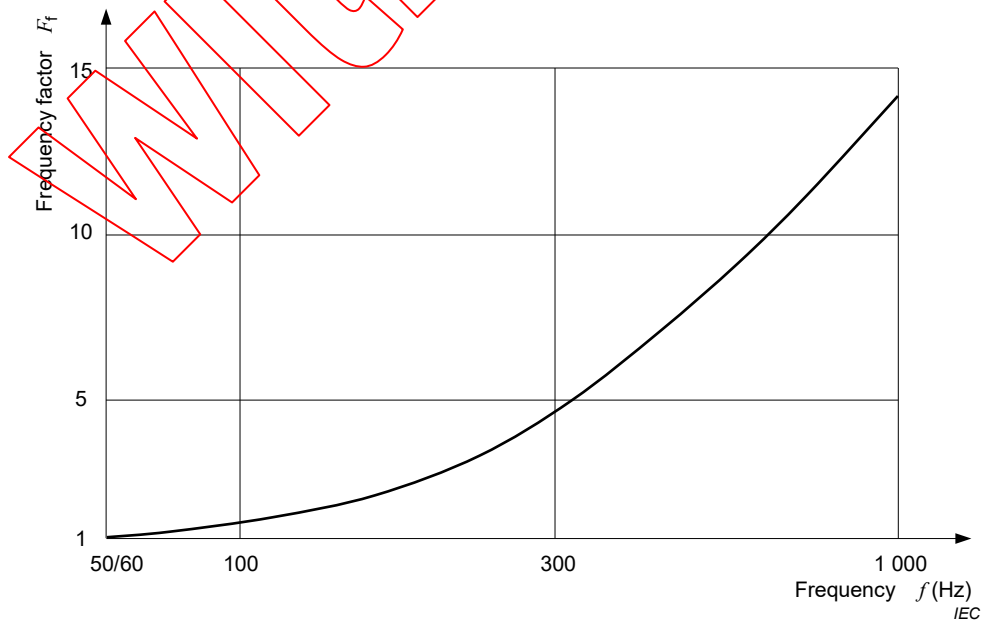


Figure 3 – Variation of the threshold of ventricular fibrillation within the frequency range 50/60 Hz to 1 000 Hz, shock durations longer than one heart period and longitudinal current paths through the trunk of the body