Australian/New Zealand Standard™

Effects of current on human beings and livestock

Part 1: General aspects

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-001, Wiring Rules.

The objective of this Standard is to provide basic guidance on the effects of shock current on human beings and livestock, for use in the establishment of electrical safety requirements.

This Standard is identical with, and has been reproduced from IEC/TR 60479-1, Ed. 4.0(2005), *Effects of current on human beings and livestock – Part 1: General aspects*.

As this Standard is reproduced from an International Standard, the following applies:

(a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.

(b) In the source text 'this technical specification' should read 'this Australian/New Zealand Standard'.

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The terms 'normative' and 'informative' are used to define the application of the annex to which it applies. A normative annex is an integral part of a Standard, whereas an informative annex is only for information and guidance.

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

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

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

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

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

NOTES

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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*