SLOVENSKI STANDARD
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Vodilo za električne inštalacije – 413. del: Zaščita pri posrednem dotiku – Samodejni odklop napajanja

Electrical installation guide - Clause 413: Explanatory notes to measures of protection against indirect contact by automatic disconnection of supply

Guide pour les installations électriques - Article 413: Notes explicatives sur les mesures de protection contre les contacts indirects par coupure automatique de l'alimentation

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Electrical installation guide –

Part 413: Protection against indirect contact – Automatic disconnection of supply

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ELECTRICAL INSTALLATION GUIDE –

Part 413: Protection against indirect contact – Automatic disconnection of supply

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example “state of the art”.

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 1200-413 which is a technical report of type 3, has been prepared by IEC technical committee 64: Electrical installations of buildings.

This technical report does not form part of IEC 364. It is a supplement to clause 413.1 of IEC 364-4-41. This report is intended to provide an explanation of the revision of clause 413.1 in the third edition of IEC 364-4-41 (1992) and of clause 481.3 of the first edition of IEC 364-4-481 (1993).

The text of this technical report is based on the following documents:

Committee draft	Report on voting
64(SEC)726	64/799/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

0. Introduction

0.1 *Principle of the protective measure*

The measure of protection by automatic disconnection of supply which is the subject of clause 413.1 of IEC 364-4-41 is intended to prevent a person being subjected to a dangerous touch voltage for a time sufficient to cause organic damage, in the event of an insulation fault.

In order to meet this requirement, in the event of such a fault the circuit protective device must interrupt the resulting fault current sufficiently quickly to prevent the touch voltage persisting long enough to be dangerous.

It follows that this protective measure relies on the combination of two conditions:

a) the provision of a conducting path, designated "the fault loop", to provide for circulation of the fault current. The composition of the fault loop depends on the type of system earthing (TN, TT or IT);

b) the interruption of the fault current within a maximum time by an appropriate protective device. This maximum time is dependent on parameters such as the magnitude of the highest touch voltage*, the probability of a fault, and the probability of a person touching equipment during a fault. Acceptable limits of touch voltage and duration are based on a knowledge of the effects of electric current on the human body.

Condition a) requires the installation of protective conductors connecting all exposed-conductive-parts of the electrical equipment supplied by the installation to an earthing system, thus forming the fault loop as shown for the different types of system earthing in the diagrams (figure 3 – TN, figure 14 – TT and figures 15-17 – IT). The protective conductors must be installed in a sound and reliable manner according to the requirements of Chapter 54 which specifies the cross-sectional areas of such conductors and the conditions to be fulfilled to ensure the reliability of the connections.

Condition b) requires the installation of protective devices the characteristics of which are defined according to the type of system earthing – TN, TT or IT.

0.2 *Effects of electric current on the human body*

The effects of electric current on the human body have been the subject of numerous studies and experiments, the results of which have been assembled and surveyed in IEC Report 479. A first edition of that Report was published in 1974 and a second edition, taking account of new knowledge in this domain, was published in two parts, the first in 1984, the second in 1987. The first part was published as a third edition in 1994.

In fact, the Report defines two components:

– the effect on the human body of electrical currents of various magnitudes and durations flowing through the body;

and

– the electrical impedance of the human body as a function of touch voltage.

These two components permit the establishment of a relationship between the prospective touch voltage and its duration, which does not usually result in harmful physiological effects on any person subjected to that touch voltage.

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* See annex B for definitions

For alternating current (15 Hz to 100 Hz) the derivation of such a relationship started with the data provided by figure 14 of IEC Report 479-1, third edition, reproduced here in figure 1. The relevant portion of that figure was zone AC-3 (between lines b and c_1) within which no organic damage was to be expected. The probability of irreversible disturbances to cardiac impulses, without ventricular fibrillation, increases with current and duration, but these effects were not considered to persist generally following the cessation of current.

Above curve c_1 (in zone AC-4) there was the risk of dangerous physiological effects such as cardiac arrest, breathing arrest and heavy burns, the probability of which increased with magnitude of current and time up to about 5 % at line c_2.

The problem was to define a suitable current-duration relationship within zone AC-3 which would serve as a basis for a proposal for a voltage-duration curve from which practical limits of touch voltage and duration could be derived.

Neither of the boundaries to zone AC-3 provided an acceptable solution to the problem. Bearing in mind the qualifications with regard to accuracy attached to such data, it was clear that the desired current-duration relationship must incorporate a suitable margin of safety between itself and the upper boundary. On the other hand, the adoption of the lower boundary was considered to be over-cautious.

A similar problem arose when the data given in edition 1 of Report 479 was used to derive a current-duration relationship. At that time a curve was approved by TC 64 which had a certain margin of safety below the boundary of zone AC-4.

With these points in mind the curve marked "Lc" in figure 1 was adopted because it was consistent with the former decision on the size of the margin below the boundary with zone AC-4, and at the same time recognised the revised conclusions in the second edition of IEC 479 on the degree of danger arising from currents of various durations through the human body.

It was considered that curve "Lc" (a function of disconnection time and current) was a reasonable basis for the establishment of disconnection times as a function of prospective touch voltage (see curve L of figure 2), to be used with the method of protection by automatic disconnection of supply.

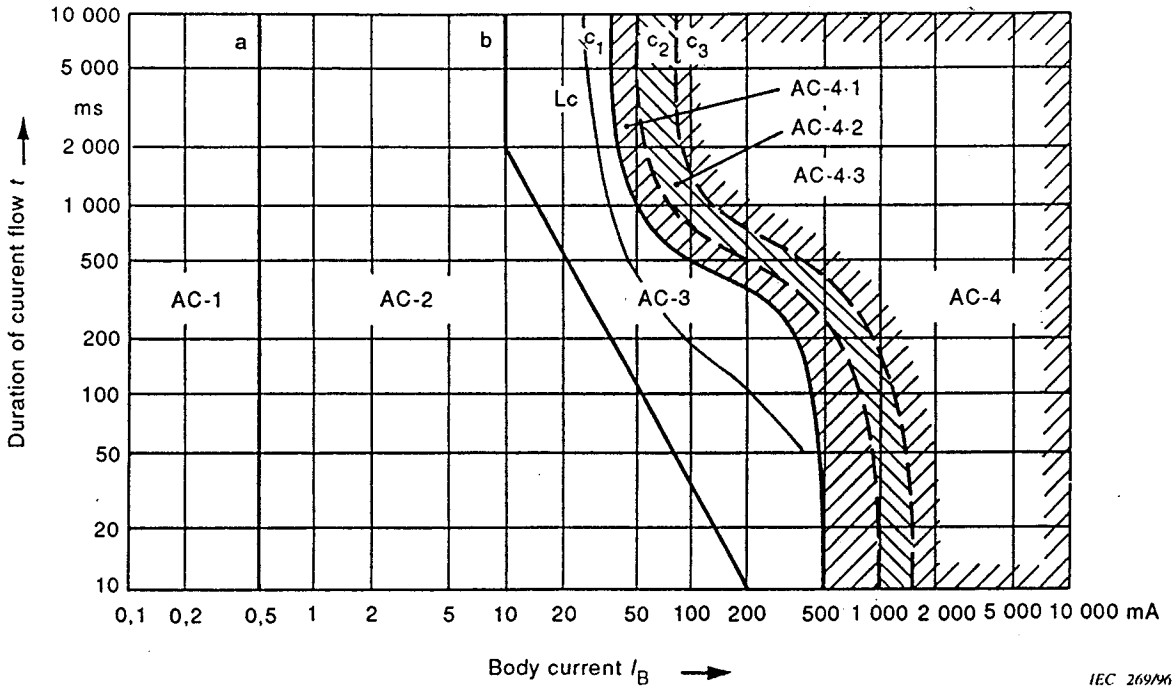

Figure 1 – Time/current zones of effects of alternating current (15 Hz to 100 Hz) on persons
(derived from figure 14, IEC 479-1, third edition)

Zone designation	Zone limits	Physiological effects
AC-1	Below line a	Usually no reaction effects
AC-2	Between line a and curve b	Usually no harmful physiological effects
AC-3	Between curves b and c_1	Usually no organic damage to be expected. Likelihood of muscular contractions and difficulty in breathing, reversible disturbances of formation and conduction of impulses in the heart, including atrial fibrillation and transient cardiac arrest without ventricular fibrillation increasing with current magnitude and time.
AC-4	Above curve c_1	In addition to the effects of Zone AC-3, probability of ventricular fibrillation increasing from about 5 % at curve c_2 up to about 50 % at curve c_3 and above 50 % beyond curve c_3. Increasing with current magnitude and time, pathophysiological effects such as cardiac arrest, breathing arrest and heavy burns may occur.

0.3 *Electrical impedance of the human body*

With regard to the electrical impedance of the human body to be considered for the determination of touch voltage, two aspects are relevant:

- the most probable path of the fault current in the body of a person;
- the environmental conditions, principally in regard to the presence of water and the contact of persons with earth.

The electrical impedance paths in different parts of the human body, i.e. hand to hand, hand to foot, were reported in IEC 479, second edition. The values were dependent on the applied voltage. The condition of the skin was responsible for a large proportion of the impedance. In order that touch voltage limits derived from body impedance should be on the safe side, the lowest impedance values given in IEC 479-1 (table I) which are exceeded by 95 % of the population, were chosen.

A current path from two hands to both feet was assumed, this being the path which has the least resistance and involves the heart muscles to the greatest extent.

0.4 *Situations*

Taking account of conditions encountered in practice, the normal situation was identified having the following general characteristics:

- dry or moist locations (or places);
- floor presenting significant resistance.

NOTE – For particular situations, see annex C.

Conditions for protection in normal situations were established taking into account the electrical impedance Z:

$$Z = 1000 + 0{,}5\ Z_{T5\%} \text{ (in ohms)} \quad (1)$$

The value of 1000 Ω was chosen as a contingency to cover both the presence of footwear and floor resistance and was a compromise. Experience and measurement for dry locations showed practical values over a very wide range; typical footwear and floor surfaces having values of at least 1000 Ω. It was considered that the adoption of such a value provided a substantial additional margin of safety. It was recognised that where environmental conditions are very unfavourable, such as exposure to wet conditions, a lower value of impedance should be used, see annex C.

$Z_{T5\%}$ is the value of total body impedance stated in IEC Report 479-1, table I that is not exceeded by 5 % of the population (the lowest figures tabulated).

The value of $Z_{T5\%}$ was based on the assumption that the body resistance is dependent on the prospective value of the touch voltage (U_t)*. The touch voltage is the potential which could be applied to the body if there were no shock current flowing. In fact the body is likely to experience a rather lower voltage (U_c) during the current flow, so that such an assumption implied a further margin of safety in the derived value of touch voltage.

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* See annex B for definitions.

The coefficient 0,5 in equation (1) takes account of the double contact two hands to two feet, as given in figure 2 of IEC Report 479-1, second edition, being given for contact between one hand and one foot.

Using the IEC data in the manner explained above, the required relationship between prospective touch voltage and disconnection time for the normal situation was derived as shown in table A and is illustrated in figure 2.

Specific values given in table A as a function of prospective touch voltage U_t are:

- the electrical impedance Z determined as previously indicated;
- the current I passing through the human body;
- the disconnection time t determined from the curve Lc of figure 1.

Table A – The relationship between prospective touch voltage and maximum disconnection time

Prospective touch voltage U_t V	Z Ω	I mA	t s
≤50	1725	29	∞
75	1625	46	0,60
100	1600	62	0,40
125	1562	80	0,33
220	1500	147	0,18
300	1460	205	0,12
400	1425	280	0,07
500	1400	350	0,04

The value of 50 V is defined as the conventional touch voltage limit (U_L).

Chapter 41 (clause 413.1) deals with the general case corresponding to the normal situation for which the conventional touch voltage limit is AC 50 V or DC 120 V ripple-free. For other conditions see annex C.

0.5 *Main equipotential bonding*

In order to avoid the transmission of potentials by metallic wiring systems and by other services coming from outside the building, sub-clause 413.1.2.1 requires the provision of main equipotential bonding connecting all extraneous-conductive-parts at their entry into the building to the main protective conductor.

The main equipotential bonding reduces the prospective touch voltage in case of a fault in the corresponding electrical installation, whatever the type of system earthing.

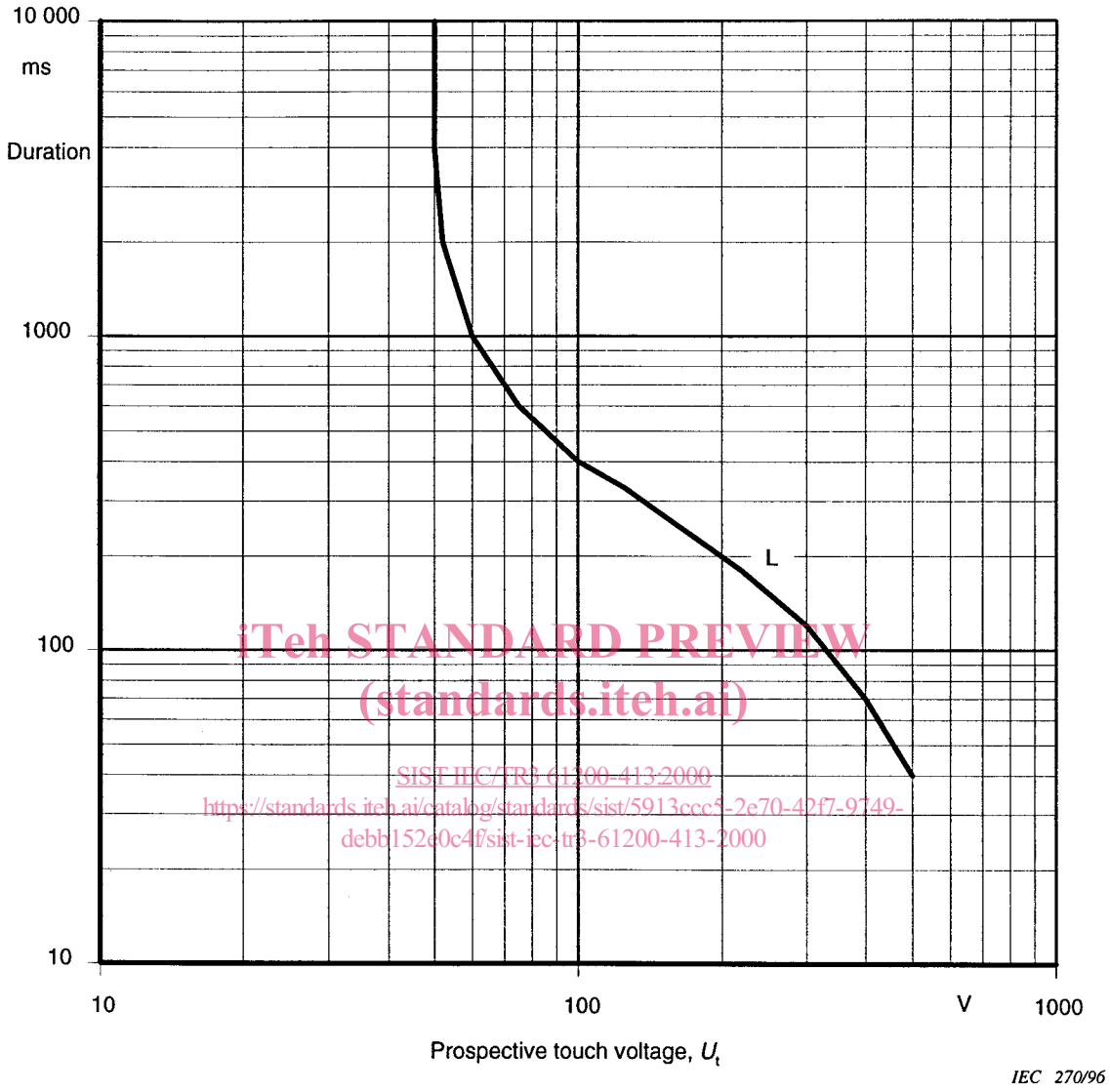

Figure 2 – Maximum duration of prospective touch voltage U_t, for normal situations

ELECTRICAL INSTALLATION GUIDE –

Part 413: Protection against indirect contact – Automatic disconnection of supply

1 Scope

IEC 1200-413 is a technical report applicable to electrical installations. It contains a compilation of comments, explanations, examples and electrical systems in order to facilitate the use of IEC 364-4-41.

2 Reference documents

IEC 38: 1983, *IEC standard voltages*

IEC 50(826): 1982, *International Electrotechnical Vocabulary (IEV) – Chapter 826: Electrical installations of buildings*

IEC 364-4-473: 1977, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 47: Application of protective measures for safety – Section 473: Measures of protection against overcurrent*

IEC 364-4-481: 1993, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 48: Choice of protective measures as a function of external influences – Section 481: Selection of measures for protection against electric shock in relation to external influences*

IEC 364-7-701: 1984, *Electrical installations of buildings – Part 7: Requirements for special installations or locations – Section 701: Locations containing a bath tub or shower basin*

IEC 364-7-702: 1983, *Electrical installations of buildings – Part 7: Requirements for special installations or locations – Section 702: Swimming pools*

IEC 364-7-704: 1989, *Electrical installations of buildings – Part 7: Requirements for special installations or locations – Section 704: Construction and demolition site installations*

IEC 364-7-705: 1984, *Electrical installations of buildings – Part 7: Requirements for special installations or locations – Section 705: Electrical installations of agricultural and horticultural premises*

IEC 479-1: 1984, *Effects of current passing through the human body – Part 1: General aspects – Second edition*

IEC 479-1: 1994, *Effects of current on human beings and livestock – Part 1: General aspects – Third edition*

IEC 479-2: 1987, *Effects of current passing through the human body – 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*

IEC 755: 1983, *General requirements for residual current operated protective devices*