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Edition 5.0 2005-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

Low-voltage electrical installations –
Part 4-41: Protection for safety – Protection against electric shock

Installations électriques à basse tension –
Partie 4-41: Protection pour assurer la sécurité – Protection contre les chocs électriques

IEC 60364-4-41:2005

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 4-41: Protection for safety – Protection against electric shock

FOREWORD

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International Standard IEC 60364-4-41 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fifth edition cancels and replaces the fourth edition, published in 2001, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– adoption of IEC 61140 terminology;
– layout rationalized on basis of complete protective measures (i.e. appropriate practical combinations of protective provision in normal service (direct contact protection) and protective provision in case of a fault (indirect contact protection);

– requirements of 471 and 481, which were included in the fourth edition have been rationalized
– disconnection requirements for TT systems clarified;
– IT systems considered more fully;
– requirements in certain cases for additional protection of socket-outlets by means of a 30 mA RCD, where the protective measure is automatic disconnection of supply.

The text of this standard is based on the following documents:

FDIS	Report on voting
64/1489/FDIS	64/1500/RVD

Full information on the voting for the approval of this standard 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.

It has the status of a group safety publication in accordance with IEC Guide 104.

The Part 4 series comprises the following parts under the general title *Low-voltage electrical installations:*

Part 4-41: Protection for safety – Protection against electric shock

Part 4-42: Protection for safety – Protection against thermal effects

Part 4-43: Protection for safety – Protection against overcurrent

Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances

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

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

410 Introduction

This Part 4-41 of IEC 60364 deals with protection against electric shock as applied to electrical installations. It is based on IEC 61140 which is a basic safety standard that applies to the protection of persons and livestock. IEC 61140 is intended to give fundamental principles and requirements that are common to electrical installations and equipment or are necessary for their co-ordination.

The fundamental rule of protection against electric shock, according to IEC 61140, is that hazardous-live-parts must not be accessible and accessible conductive parts must not be hazardous live, neither under normal conditions nor under single fault conditions.

According to 4.2 of IEC 61140, protection under normal conditions is provided by basic protective provisions and protection under single fault conditions is provided by fault protective provisions. Alternatively, protection against electric shock is provided by an enhanced protective provision, which provides protection under normal conditions and under single fault conditions.

This standard has the status of a group safety publication (GSP) for protection against electric shock.

In the fourth edition of IEC 60364 (2001):

– protection under normal conditions (now designated basic protection) was referred to as protection against direct contact and
– protection under fault conditions (now designated fault protection) was referred to as protection against indirect contact.

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 4-41: Protection for safety – Protection against electric shock

410.1 Scope

Part 4-41 of IEC 60364 specifies essential requirements regarding protection against electric shock, including basic protection (protection against direct contact) and fault protection (protection against indirect contact) of persons and livestock. It deals also with the application and co-ordination of these requirements in relation to external influences.

Requirements are also given for the application of additional protection in certain cases.

410.2 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 60364-5-52, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems* [1)]

IEC 60364-5-54, *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors*

IEC 60364-6, *Low-voltage electrical installations – Part 6: Verification* [2)]

IEC 60439-1, Low-*voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*

IEC 60449, *Voltage bands for electrical installations of buildings*

IEC 60614 (all parts), *Conduits for electrical installations – Specification*

IEC 61084 (all parts), *Cable trunking and ducting systems for electrical installations*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61386 (all parts), *Conduit systems for electrical installations*

IEC 61558-2-6, *Safety of power transformers, power supply units and similar – Part 2-6: Particular requirements for safety isolating transformers for general use*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

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1) A new edition is currently under consideration.

2) To be published.

410.3 General requirements

410.3.1 In this standard the following specification of voltages is intended unless otherwise stated:

– a.c. voltages are r.m.s.;

– d.c. voltages are ripple-free.

Ripple-free is conventionally defined as an r.m.s. ripple voltage of not more than 10 % of the d.c. component.

410.3.2 A protective measure shall consist of

– an appropriate combination of a provision for basic protection and an independent provision for fault protection, or

– an enhanced protective provision which provides both basic protection and fault protection.

Additional protection is specified as part of a protective measure under certain conditions of external influences and in certain special locations (see the corresponding Part 7 of IEC 60364).

NOTE 1 For special applications, protective measures which do not follow this concept are permitted (see 410.3.5 and 410.3.6).

NOTE 2 An example of an enhanced protective measure is reinforced insulation.

410.3.3 In each part of an installation one or more protective measures shall be applied, taking account of the conditions of external influence.

The following protective measures generally are permitted:

– automatic disconnection of supply (Clause 411),

– double or reinforced insulation (Clause 412),

– electrical separation for the supply of one item of current-using equipment (Clause 413),

– extra-low-voltage (SELV and PELV) (Clause 414).

The protective measures applied in the installation shall be considered in the selection and erection of equipment.

For particular installations see 410.3.4 to 410.3.9.

NOTE In electrical installations the most commonly used protective measure is automatic disconnection of supply.

410.3.4 For special installations or locations, the particular protective measures in the corresponding Part 7 of IEC 60364 shall be applied.

410.3.5 The protective measures, specified in Annex B, i.e. the use of obstacles and placing out of reach, shall only be used in installations accessible to

– skilled or instructed persons, or

– persons under the supervision of skilled or instructed persons.

410.3.6 The protective measures, specified in Annex C, i.e.

– non-conducting location,
– earth-free local equipotential bonding,
– electrical separation for the supply of more than one item of current-using equipment,

may be applied only when the installation is under the supervision of skilled or instructed persons so that unauthorized changes cannot be made.

410.3.7 If certain conditions of a protective measure cannot be met, supplementary provisions shall be applied so that the protective provisions together achieve the same degree of safety.

NOTE An example of the application of this rule is given in 411.7.

410.3.8 Different protective measures applied to the same installation or part of an installation or within equipment shall have no influence on each other such that failure of one protective measure could impair the other protective measures.

410.3.9 The provision for fault protection (protection against indirect contact) may be omitted for the following equipment:

– metal supports of overhead line insulators which are attached to the building and are placed out of arm's reach;

– steel reinforced concrete poles of overhead lines in which the steel reinforcement is not accessible;
– exposed-conductive-parts which, owing to their reduced dimensions (approximately 50 mm x 50 mm) or their disposition cannot be gripped or come into significant contact with a part of the human body and provided that connection with a protective conductor could only be made with difficulty or would be unreliable.

  NOTE 1 This exemption applies, for example, to bolts, rivets, nameplates and cable clips.

  NOTE 2 In the USA, all exposed-conductive-parts are bonded to the protective conductor.

– metal tubes or other metal enclosures protecting equipment in accordance with Clause 412.

411 Protective measure: automatic disconnection of supply

411.1 General

Automatic disconnection of supply is a protective measure in which

– basic protection is provided by basic insulation of live parts or by barriers or enclosures, in accordance with Annex A, and
– fault protection is provided by protective equipotential bonding and automatic disconnection in case of a fault in accordance with 411.3 to 411.6.

NOTE 1 Where this protective measure is applied, Class II equipment may also be used.

Where specified, additional protection is provided by a residual current protective device (RCD) with rated residual operating current not exceeding 30 mA in accordance with 415.1.

NOTE 2 Residual current monitors (RCMs) are not protective devices but they may be used to monitor residual currents in electrical installations. RCMs produce an audible or audible and visual signal when a preselected value of residual current is exceeded

411.2 Requirements for basic protection

All electrical equipment shall comply with one of the provisions for basic protection (protection against direct contact) described in Annex A or, where appropriate, Annex B.

411.3 Requirements for fault protection

411.3.1 Protective earthing and protective equipotential bonding

411.3.1.1 Protective earthing

Exposed-conductive-parts shall be connected to a protective conductor under the specific conditions for each type of system earthing as specified in 411.4 to 411.6.

Simultaneously accessible exposed-conductive-parts shall be connected to the same earthing system individually, in groups or collectively.

Conductors for protective earthing shall comply with IEC 60364-5-54.

Each circuit shall have available a protective conductor connected to the relevant earthing terminal.

411.3.1.2 Protective equipotential bonding

In each building the earthing conductor, the main earthing terminal and the following conductive parts shall be connected to the protective equipotential bonding:

– metallic pipes supplying services into the building, e.g. gas, water;

– structural extraneous-conductive-parts if accessible in normal use, metallic central heating and air-conditioning systems;

– metallic reinforcements of constructional reinforced concrete, if reasonably practicable.

Where such conductive parts originate outside the building, they shall be bonded as close as practicable to their point of entry within the building.

Conductors for protective equipotential bonding shall comply with IEC 60364-5-54.

Any metallic sheath of telecommunication cables shall be connected to the protective equipotential bonding, taking account of the requirements of the owners or operators of these cables.

411.3.2 Automatic disconnection in case of a fault

411.3.2.1 Except as provided by 411.3.2.5 and 411.3.2.6, a protective device shall automatically interrupt the supply to the line conductor of a circuit or equipment in the event of a fault of negligible impedance between the line conductor and an exposed-conductive-part or a protective conductor in the circuit or equipment within the disconnection time required in 411.3.2.2, 411.3.2.3 or 411.3.2.4.

NOTE 1 Higher values of disconnection time than those required in this subclause may be admitted in systems for electricity distribution to the public and power generation and transmission for such systems.

NOTE 2 Lower values of disconnection time may be required for special installations or locations according to the relevant Part 7 of IEC 60364.

NOTE 3 For IT systems, automatic disconnection is not usually required on the occurrence of a first fault (see 411.6.1). For the requirements for disconnection after the first fault see 411.6.4.

NOTE 4 In Belgium 411.3.2.3 is not applicable. The Belgian Wiring Rules (AREI-RGIE) do not specify differences in automatic disconnection times between distribution circuits and final circuits.

NOTE 5 In Norway for an installation forming part of an IT system and supplied from a public network, automatic disconnection at the first fault is required

411.3.2.2 The maximum disconnection time stated in Table 41.1 shall be applied to final circuits not exceeding 32A.

Table 41.1 – Maximum disconnection times

System	$50\ V < U_o \leq 120\ V$ s		$120\ V < U_o \leq 230\ V$ s		$230\ V < U_o \leq 400\ V$ s		$U_o > 400\ V$ s	
	a.c.	d.c.	a.c.	d.c.	a.c.	d.c.	a.c.	d.c.
TN	0,8	Note 1	0,4	5	0,2	0,4	0,1	0,1
TT	0,3	Note 1	0,2	0,4	0,07	0,2	0,04	0,1
Where in TT systems the disconnection is achieved by an overcurrent protective device and the protective equipotential bonding is connected with all extraneous-conductive-parts within the installation, the maximum disconnection times applicable to TN systems may be used. U_o is the nominal a.c. or d.c. line to earth voltage.								
NOTE 1 Disconnection may be required for reasons other than protection against electric shock. NOTE 2 Where disconnection is provided by an RCD see Note to 411.4.4, Note 4 to 411.5.3 and Note to 411.6.4 b). NOTE 3 In Belgium, the last column U_o >400 V is not applicable. Above 400 V, the Belgian safety curve as given in the Belgian Wiring Rules applies. NOTE 4 In the Netherlands the maximum disconnection time stated in Table 41.1 is applied to all circuits not exceeding 32 A and all circuits supplying socket-outlets. NOTE 5 In China the maximum disconnecting time stated in Table 41.1 is applied to final circuits which supply hand-held equipment or portable equipment.								

411.3.2.3 In TN systems, a disconnection time not exceeding 5 s is permitted for distribution circuits, and for circuits not covered by 411.3.2.2.

411.3.2.4 In TT systems, a disconnection time not exceeding 1 s is permitted for distribution circuits and for circuits not covered by 411.3.2.2.

411.3.2.5 For systems with nominal voltage U_o greater than 50 V a.c. or 120 V d.c., automatic disconnection in the time required by 411.3.2.2, 411.3.2.3 or 411.3.2.4 as appropriate is not required if in the event of a fault to a protective conductor or earth, the output voltage of the source is reduced in not more than 5 s to 50 V a.c. or 120 V d.c. or less. In such cases consideration shall be given to disconnection as required for reasons other than electric shock.

411.3.2.6 If automatic disconnection according to 411.3.2.1 cannot be achieved in the time required by 411.3.2.2, 411.3.2.3, or 411.3.2.4 as appropriate, supplementary protective equipotential bonding shall be provided in accordance with 415.2.

411.3.3 Additional protection

In a.c. systems, additional protection by means of a residual current protective device (RCD) in accordance with 415.1 shall be provided for

– socket-outlets with a rated current not exceeding 20 A that are for use by ordinary persons and are intended for general use; and

NOTE 1 An exemption may be made for:

– socket-outlets for use under the supervision of skilled or instructed persons, e.g., in some commercial or industrial locations or

– a specific socket-outlet provided for connection of a particular item of equipment.

NOTE 2 In Spain and Ireland additional protection is provided for socket-outlets with a rated current up to 32 A intended for use by ordinary persons.

NOTE 3 In Belgium, every electrical installation under the supervision of ordinary persons must be protected by a RCD with a rated operating residual current not exceeding 300 mA; for circuits supplying bathrooms, washing machines, dishwashers, etc, an additional protection by means of a RCD with a rated residual operating current not exceeding 30 mA is mandatory; the above is valid for electrical installations of which the earthing resistance is lower than 30 Ω; in case of earthing resistance higher than 30 Ω and lower than 100 Ω, additional RCDs with a rated operating residual current not exceeding 100 mA should be provided. An earthing resistance higher than 100 Ω is not permitted.

NOTE 4 In Norway all commercial and industrial companies are covered by regulations requiring procedures for qualifications and training of employees. Except for areas open for the public, socket-outlets in such locations are normally not considered to be for general use of ordinary people. Socket-outlets in dwellings and BA2 locations are intended for general use by ordinary people.

NOTE 5 In China a 30 mA RCD is not required for the socket-outlet supplying air conditioning equipment and erected in position not accessible to persons.

– mobile equipment with a current rating not exceeding 32 A for use outdoors.

411.4 TN system

411.4.1 In TN systems the integrity of the earthing of the installation depends on the reliable and effective connection of the PEN or PE conductors to earth. Where the earthing is provided from a public or other supply system, compliance with the necessary conditions external to the installation is the responsibility of the supply network operator.

NOTE 1 Examples of conditions include:

– the PEN is connected to earth at a number of points and is installed in such a way as to minimize the risk of a break in the PEN conductor;

– $R_B/R_E \leq 50/(U_0 - 50)$

where

R_B is the earth electrode resistance, in ohms, of all earth electrodes in parallel;

R_E is the minimum contact resistance with earth, in ohms, of extraneous-conductive-parts not connected to a protective conductor, through which a fault between line and earth may occur;

U_o is the nominal a.c. r.m.s. voltage to earth, in volts.

NOTE 2 In Germany compliance with condition $R_B/R_E \leq 50 / (U_o - 50)$ is compulsory for the supply network operator.

411.4.2 The neutral point or the midpoint of the power supply system shall be earthed. If a neutral point or midpoint is not available or not accessible, a line conductor shall be earthed.

Exposed-conductive-parts of the installation shall be connected by a protective conductor to the main earthing terminal of the installation which shall be connected to the earthed point of the power supply system.

NOTE 1 If other effective earth connections exist, it is recommended that the protective conductors also be connected to such points wherever possible. Earthing at additional points, distributed as evenly as possible, may be necessary to ensure that the potentials of protective conductors remain, in case of a fault, as near as possible to that of earth.

In large buildings such as high-rise buildings, additional earthing of protective conductors is not possible for practical reasons. In such buildings protective-equipotential-bonding between protective conductors and extraneous-conductive-parts has, however, a similar function.

NOTE 2 It is recommended that protective conductors (PE and PEN) should be earthed where they enter any buildings or premises taking account of any diverted neutral currents.

411.4.3 In fixed installations, a single conductor may serve both as a protective conductor and as a neutral conductor (PEN conductor) provided that the requirements of 543.4 of IEC 60364-5-54 are satisfied. No switching or isolating device shall be inserted in the PEN conductor.

NOTE 1 In Switzerland the main building overcurrent protective device with integrated isolating device in the PEN conductor forms the interface between the network and the installation of the building.

NOTE 2 In Norway, the use of a PEN conductor downstream of the main distribution board is not allowed.

411.4.4 The characteristics of the protective devices (see 411.4.5) and the circuit impedances shall fulfil the following requirement:

$$Z_s \times I_a \leq U_o$$

where

Z_s is the impedance in ohms (Ω) of the fault loop comprising

– the source,

– the line conductor up to the point of the fault, and

– the protective conductor between the point of the fault and the source;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in 411.3.2.2,or 411.3.2.3. When a residual current protective device (RCD) is used this current is the residual operating current providing disconnection in the time specified in 411.3.2.2,or 411.3.2.3:

U_o is the nominal a.c. or d.c. line to earth voltage in volts (V).

NOTE Where compliance with this subclause is provided by an RCD, the disconnecting times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$).

411.4.5 In TN systems, the following protective devices may be used for fault protection (protection against indirect contact):

– overcurrent protective devices;

– residual current protective devices (RCDs).

NOTE 1 Where an RCD is used for fault protection the circuit should also be protected by an overcurrent protective device in accordance with IEC 60364-4-43.

A residual current protective device (RCD) shall not be used in TN-C systems.

Where an RCD is used in a TN-C-S system, a PEN conductor shall not be used on the load side. The connection of the protective conductor to the PEN conductor shall be made on the source side of the RCD.

NOTE 2 Where discrimination between RCDs is necessary, see 535.3 of IEC 60364-5-53.

411.5 TT system

411.5.1 All exposed-conductive-parts collectively protected by the same protective device shall be connected by the protective conductors to an earth electrode common to all those parts. Where several protective devices are utilized in series, this requirement applies separately to all the exposed-conductive-parts protected by each device.

The neutral point or the mid-point of the power supply system shall be earthed. If a neutral point or mid-point is not available or not accessible, a line conductor shall be earthed.

NOTE In the Netherlands the resistance of the earth electrode should be as low as practicable, but in any case not exceeding 166 Ω.

411.5.2 Generally in TT systems, RCDs shall be used for fault protection . Alternatively, overcurrent protective devices may be used for fault protection provided a suitably low value of Z_s is permanently and reliably assured.

NOTE 1 Where an RCD is used for fault protection the circuit should also be protected by an overcurrent protective device in accordance with IEC 60364-4-43.

NOTE 2 The use of fault-voltage operated protective devices is not covered by this standard.

NOTE 3 In the Netherlands where an earthing system is used for more than one electrical installation compliance with 411.5.3 shall remain effective in case of

– any single break of the earthing system,

– failure of any residual current protective device (RCD).

411.5.3 Where a residual current protective device (RCD) is used for fault protection, the following conditions shall be fulfilled:

i) the disconnection time as required by 411.3.2.2 or 411.3.2.4, and

ii) $R_A \times I_{\Delta n} \leq 50$ V

where

R_A is the sum of the resistance in Ω of the earth electrode and the protective conductor for the exposed conductive-parts,

$I_{\Delta n}$ is the rated residual operating current of the RCD.

NOTE 1 Fault protection is provided in this case also if the fault impedance is not negligible.

NOTE 2 Where discrimination between RCDs is necessary see 535.3 of IEC 60364-5-53.

NOTE 3 Where R_A is not known, it may be replaced by Z_S.

NOTE 4 The disconnection times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$).

411.5.4 Where an over-current protective device is used the following condition shall be fulfilled:

$$Z_s \times I_a \leq U_o$$

where

Z_s is the impedance in Ω of the fault loop comprising

- the source,
- the line conductor up to the point of the fault,
- the protective conductor of the exposed-conductive-parts,
- the earthing conductor,
- the earth electrode of the installation and
- the earth electrode of the source;

I_a is the current in A causing the automatic operation of the disconnecting device within the time specified in 411.3.2.2 or 411.3.2.4;

U_o is the nominal a.c. or d.c. line to earth voltage.

411.6 IT system

411.6.1 In IT systems live parts shall be insulated from earth or connected to earth through a sufficiently high impedance. This connection may be made either at the neutral point or mid-point of the system or at an artificial neutral point. The latter may be connected directly to earth if the resulting impedance to earth is sufficiently high at the system frequency. Where no neutral point or mid-point exists, a line conductor may be connected to earth through a high impedance.

The fault current is then low in the event of a single fault to an exposed-conductive-part or to earth and automatic disconnection in accordance with 411.3.2 is not imperative provided the condition in 411.6.2 is fulfilled. Provisions shall be taken, however, to avoid risk of harmful pathophysiological effects on a person in contact with simultaneously accessible exposed-conductive-parts in the event of two faults existing simultaneously.