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Cinquième édition
Fifth edition
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PUBLICATION GROUPÉE DE SÉCURITÉ
GROUP SAFETY PUBLICATION

Installations électriques à basse tension –

Partie 4-41:
Protection pour assurer la sécurité –
Protection contre les chocs électriques

Low-voltage electrical installations –

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

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

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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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 ≤ 120 V s		120 V < U_o ≤ 230 V s		230 V < U_o ≤ 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.

NOTE 1 To reduce overvoltage or to damp voltage oscillation, it may be necessary to provide earthing through impedances or artificial neutral points, and the characteristics of these should be appropriate to the requirements of the installation.

NOTE 2 In Norway, where more installations are likely to have galvanic connection to the same distribution network, all final circuits in IT installations with galvanic connection to a public IT distribution network need to be disconnected within the time specified for a TN system (see Table 41.1) 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.

411.6.2 Exposed-conductive-parts shall be earthed individually, in groups, or collectively.

The following condition shall be fulfilled:

– in a.c. systems $R_A \times I_d \leq 50$ V

– in d.c. systems $R_A \times I_d \leq 120$ V

where

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

I_d is the fault current in A of the first fault of negligible impedance between a line conductor and an exposed-conductive-part. The value of I_d takes account of leakage currents and the total earthing impedance of the electrical installation.

411.6.3 In IT systems the following monitoring devices and protective devices may be used:

– insulation monitoring devices (IMDs);

– residual current monitoring devices (RCMs)

– insulation fault location systems;

– overcurrent protective devices;

– residual current protective devices (RCDs).

NOTE Where a residual current operating device (RCD) is used, tripping of the RCD in event of a first fault cannot be excluded due to capacitive leakage currents.

411.6.3.1 In cases where an IT system is used for reasons of continuity of supply, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed-conductive-parts or to earth. This device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

If there are both audible and visible signals, it is permissible for the audible signal to be cancelled.

NOTE 1 It is recommended that a first fault be eliminated with the shortest practicable delay.

NOTE 2 In the Netherlands for an IT supply system used for reasons of continuity of supply, and where the system is connected to earth through an impedance (see 411.6.1), an RCM may be provided to monitor the system instead of an IMD.

411.6.3.2 Except where a protective device is installed to interrupt the supply in the event of the first earth fault, an RCM or an insulation fault location system may be provided to indicate the occurrence of a first fault from a live part to exposed-conductive-parts or to earth. This device shall initiate an audible and/or visual signal, which shall continue as long as the fault persists.

If there are both audible and visual signals it is permissible for the audible signal to be cancelled, but the visual alarm shall continue as long as the fault persists.

NOTE It is recommended that a first fault be eliminated with the shortest practicable delay.

411.6.4 After the occurrence of a first fault, conditions for automatic disconnection of supply in the event of a second fault occurring on a different live conductor shall be as follows:

a) Where exposed-conductive-parts are interconnected by a protective conductor collectively earthed to the same earthing system, the conditions similar to a TN system apply and the following conditions shall be fulfilled where the neutral conductor is not distributed in a.c. systems and in d.c. systems where the mid-point conductor is not distributed:

$$2I_a Z_s \leq U$$

or where the neutral conductor or mid-point conductor respectively is distributed:

$$2I_a Z'_s \leq U_o$$

where

U_o is the nominal a.c. or d.c. voltage, in V, between line conductor and neutral conductor or mid-point conductor, as appropriate;

U is the nominal a.c. or d.c. voltage in V between line conductors;

Z_s is the impedance in Ω of the fault loop comprising the line conductor and the protective conductor of the circuit;

Z'_s is the impedance in Ω of the fault loop comprising the neutral conductor and the protective conductor of the circuit;

I_a is the current in A causing operation of the protective device within the time required in 411.3.2.2 for TN systems or 411.3.2.3.

NOTE 1 The time stated in Table 41.1 of 411.3.2.2 for the TN system is applicable to IT systems with a distributed or non-distributed neutral conductor or mid-point conductor.

NOTE 2 The factor 2 in both formulas takes into account that in the event of the simultaneous occurrence of two faults, the faults may exist in different circuits.

NOTE 3 For fault loop impedance, the most severe case should be taken into account, e.g. a fault on the line conductor at the source and simultaneously another fault on the neutral conductor of a current-using equipment of the circuit considered.

b) Where the exposed-conductive-parts are earthed in groups or individually, the following condition applies:

$$R_A \times I_a \leq 50 \text{ V}$$

where

R_A is the sum of the resistances of the earth electrode and the protective conductor to the exposed-conductive-parts,

I_a is the current causing automatic disconnection of the disconnection device in a time complying to that for TT systems in Table 41.1 of 411.3.2.2 or in a time complying to 411.3.2.4.

NOTE 4 If compliance to the requirements of b) is provided by a residual current protective device (RCD) compliance with the disconnection times required for TT systems in Table 41.1 may require residual currents significantly higher than the rated residual operating current $I_{\Delta n}$ of the RCD applied (typically 5 $I_{\Delta n}$).

411.7 Functional extra-low voltage (FELV)

411.7.1 General

Where, for functional reasons, a nominal voltage not exceeding 50 V a.c. or 120 V d.c. is used but all the requirements of Clause 414 relating to SELV or to PELV are not fulfilled, and where SELV or PELV is not necessary, the supplementary provisions described in 411.7.2 and 411.7.3 shall be taken to ensure basic protection and fault protection . This combination of provisions is known as FELV.

NOTE Such conditions may, for example, be encountered when the circuit contains equipment (such as transformers, relays, remote-control switches, contactors) insufficiently insulated with respect to circuits at higher voltage.

411.7.2 Requirements for basic protection

Basic protection shall be provided by either

– basic insulation according to Clause A.1 corresponding to the nominal voltage of the primary circuit of the source, or

– barriers or enclosures in accordance with Clause A.2.

411.7.3 Requirements for fault protection

The exposed-conductive-parts of the equipment of the FELV circuit shall be connected to the protective conductor of the primary circuit of the source, provided that the primary circuit is subject to protection by automatic disconnection of supply described in 411.3 to 411.6.

411.7.4 Sources

The source of the FELV system shall be either a transformer with at least simple separation between windings or shall comply with 414.3.

NOTE If the system is supplied from a higher voltage system by equipment which does not provide at least simple separation between that system and the FELV system, such as autotransformers, potentiometers, semiconductor devices, etc., the output circuit is deemed to be an extension of the input circuit and should be protected by the protective measure applied in the input circuit.

411.7.5 Plugs and socket-outlets

Plugs and socket-outlets for FELV systems shall comply with all the following requirements:

– plugs shall not be able to enter socket-outlets of other voltage systems,

– socket-outlets shall not admit plugs of other voltage systems, and

– socket-outlets shall have a protective conductor contact.

412 Protective measure: double or reinforced insulation

412.1 General

412.1.1 Double or reinforced insulation is a protective measure in which

– basic protection is provided by basic insulation, and fault protection is provided by supplementary insulation, or

– basic and fault protection is provided by reinforced insulation between live parts and accessible parts.

NOTE This protective measure is intended to prevent the appearance of dangerous voltage on the accessible parts of electrical equipment through a fault in the basic insulation.

412.1.2 The protective measure by double or reinforced insulation is applicable in all situations, unless some limitations are given in the corresponding Part 7 of IEC 60364.

412.1.3 Where this protective measure is to be used as the sole protective measure (i.e. where a whole installation or circuit is intended to consist entirely of equipment with double insulation or reinforced insulation), it shall be verified that the installation or circuit concerned will be under effective supervision in normal use so that no change is made that would impair the effectiveness of the protective measure. This protective measure shall not therefore be applied to any circuit that includes a socket-outlet or where a user may change items of equipment without authorization.

412.2 Requirements for basic protection and fault protection

412.2.1 Electrical equipment

Where the protective measure, using double or reinforced insulation, is used for the complete installation or part of the installation, electrical equipment shall comply with one of the following subclauses:

– 412.2.1.1; or

– 412.2.1.2 and 412.2.2; or

– 412.2.1.3 and 412.2.2.

412.2.1.1 Electrical equipment shall be of the following types, and type tested and marked to the relevant standards:

– electrical equipment having double or reinforced insulation (Class II equipment);

– electrical equipment declared in the relevant product standard as equivalent to Class II, such as assemblies of electrical equipment having total insulation (see IEC 60439-1).

NOTE This equipment is identified by the symbol  reference IEC 60417-5172 (DB[3]:2002-10): Class II equipment.

412.2.1.2 Electrical equipment having basic insulation only shall have supplementary insulation applied in the process of erecting the electrical installation, providing a degree of safety equivalent to electrical equipment according to 412.2.1.1 and complying with 412.2.2.1 to 412.2.2.3.

NOTE The symbol  should be fixed in a visible position on the exterior and interior of the enclosure. See IEC 60417-5019 (DB: 2002-10): Protective earth (ground).

412.2.1.3 Electrical equipment having uninsulated live parts shall have reinforced insulation applied in the process of erecting the electrical installation, providing a degree of safety equivalent to electrical equipment according to 412.2.1.1 and complying with 412.2.2.2 and 412.2.2.3; such insulation being recognized only where constructional features prevent the application of double insulation.

NOTE The symbol  should be fixed in a visible position on the exterior and interior of the enclosure. IEC reference IEC 60417-5019 (DB: 2002-10): Protective earth (ground).

412.2.2 Enclosures

412.2.2.1 The electrical equipment being ready for operation, all conductive parts separated from live parts by basic insulation only, shall be contained in an insulating enclosure affording at least the degree of protection IPXXB or IP2X.

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3 "DB" refers to the IEC on-line database.

412.2.2.2 The following requirements apply as specified:

– the insulating enclosure shall not be traversed by conductive parts likely to transmit a potential; and

– the insulating enclosure shall not contain any screws or other fixing means of insulating material which might need to be removed, or are likely to be removed, during installation and maintenance and whose replacement by metallic screws or other fixing means could impair the enclosure's insulation.

Where the insulating enclosure must be traversed by mechanical joints or connections (e.g. for operating handles of built-in apparatus), these should be arranged in such a way that protection against shock in case of a fault is not impaired.

412.2.2.3 Where lids or doors in the insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible if the lid or door is open shall be behind an insulating barrier (providing a degree of protection not less than IPXXB or IP2X) preventing persons from coming unintentionally into contact with those conductive parts. This insulating barrier shall be removable only by use of a tool or key.

412.2.2.4 Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which necessarily run through the enclosure in order to serve other items of electrical equipment whose supply circuit also runs through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be marked as PE terminals.

Exposed-conductive-parts and intermediate parts shall not be connected to a protective conductor unless specific provision for this is made in the specifications for the equipment concerned.

412.2.2.5 The enclosure shall not adversely affect the operation of the equipment protected in this way.

412.2.3 Installation

412.2.3.1 The installation of equipment mentioned in 412.2.1 (fixing, connection of conductors, etc.) shall be effected in such a way as not to impair the protection afforded in compliance with the equipment specification.

412.2.3.2 Except where 412.1.3 applies, a circuit supplying items of Class II equipment shall have a circuit protective conductor run to and terminated at each point in wiring and at each accessory.

NOTE This requirement is intended to take account of the replacement by the user of Class II equipment by Class I equipment.

412.2.4 Wiring systems

412.2.4.1 Wiring systems installed in accordance with IEC 60364-5-52 are considered to meet the requirements of 412.2 if:

– the rated voltage of the wiring system shall be not less than the nominal voltage of the system and at least 300/500 V, and

– adequate mechanical protection of the basic insulation is provided by one or more of the following:

  a) the non-metallic sheath of the cable, or

  b) non-metallic trunking or ducting complying with the IEC 61084 series, or non-metallic conduit complying with either the IEC 60614 series or the IEC 61386 series.

NOTE 1 Cable product standards do not specify impulse withstand capability, however it is considered that the insulation of the cabling system is at least equivalent to the requirement in IEC 61140 for reinforced insulation.

NOTE 2 Such a wiring system should not be identified by the symbol  IEC 60417-5172 (DB:2002-10), nor by the symbol  IEC 60417-5019 (DB:2002-10).

NOTE 3 In Italy, wiring systems installed in accordance with IEC 60364-5-52 in electrical systems with nominal voltages not higher than 690 V, are considered to meet the requirements of 412.2 if the following cables or insulated conductors are used:

- cables, provided with a non-metallic sheath, having a rated voltage one step higher than the nominal voltage of the system; or
- insulated conductors installed in insulating conduits or insulating trunkings complying with the relevant standards; or
- cables, provided with a metallic sheath, having between the conductors and the metallic sheath and between such metallic sheath and the external surface, an insulation adequate for the nominal voltage of the electrical system.

413 Protective measure: electrical separation

413.1 General

413.1.1 Electrical separation is a protective measure in which

- basic protection is provided by basic insulation of live parts or by barriers and enclosures in accordance with Annex A, and
- fault protection is provided by simple separation of the separated circuit from other circuits and from earth.

413.1.2 Except as permitted by 413.1.3, this protective measure shall be limited to the supply of one item of current-using equipment supplied from one unearthed source with simple separation.

NOTE When this protective measure is used, it is particularly important to ensure compliance of the basic insulation with the product standard.

413.1.3 Where more than one item of current-using equipment is supplied from an unearthed source with simple separation, the requirements of Clause C.3 shall be met.

413.2 Requirements for basic protection

All electrical equipment shall be subject to one of the basic protective provisions in Annex A or to the protective measure in Clause 412.

413.3 Requirements for fault protection

413.3.1 Protection by electrical separation shall be ensured by compliance with 413.3.2 to 413.3.6.

413.3.2 The separated circuit shall be supplied through a source with at least simple separation, and the voltage of the separated circuit shall not exceed 500 V.

413.3.3 Live parts of the separated circuit shall not be connected at any point to another circuit or to earth or to a protective conductor.

To ensure electrical separation, arrangements shall be such that basic insulation is achieved between circuits.

413.3.4 Flexible cables and cords shall be visible throughout any part of their length liable to mechanical damage.

413.3.5 For separated circuits the use of separate wiring systems is recommended. If separated circuits and other circuits are in the same wiring system, multi-conductor cables without metallic covering, insulated conductors in insulating conduit, insulated ducting or insulated trunking shall be used, provided that

– the rated voltage is not less than the highest nominal voltage, and
– each circuit is protected against overcurrent.

413.3.6 The exposed-conductive-parts of the separated circuit shall not be connected either to the protective conductor or exposed-conductive-parts of other circuits, or to earth.

NOTE If the exposed-conductive-parts of the separated circuit are liable to come into contact, either intentionally or fortuitously, with the exposed-conductive-parts of other circuits, protection against electric shock no longer depends solely on protection by electrical separation but on the protective provisions to which the latter exposed-conductive-parts are subject.

414 Protective measure: extra-low-voltage provided by SELV and PELV

414.1 General

414.1.1 Protection by extra-low-voltage is a protective measure which consists of either of two different extra-low-voltage systems:

– SELV; or
– PELV.

This protective measure requires:

– limitation of voltage in the SELV or PELV system to the upper limit of voltage Band I, 50 V a.c. or 120 V d.c. (see IEC 60449), and
– protective separation of the SELV or PELV system from all circuits other than SELV and PELV circuits, and basic insulation between the SELV or PELV system and other SELV or PELV systems, and
– for SELV systems only, basic insulation between the SELV system and earth.

414.1.2 The use of SELV or PELV according to Clause 414 is considered as a protective measure in all situations.

NOTE In certain cases the standards of the IEC 60364-7 series limit the value of the extra-low voltage to a value lower than 50 V a.c. or 120 V d.c..

414.2 Requirements for basic protection and fault protection

Basic protection and fault protection is deemed to be provided when

– the nominal voltage cannot exceed the upper limit of voltage Band I,
– the supply is from one of the sources listed in 414.3, and
– the conditions of 414.4 are fulfilled.

NOTE 1 If the system is supplied from a higher voltage system by equipment which provides at least simple separation between that system and the extra-low-voltage system, but which does not meet the requirements for SELV and PELV sources in 414.3, the requirements for FELV may be applicable, see 411.7.

NOTE 2 DC voltages for ELV circuits generated by a semiconductor convertor (see IEC 60146-2) require an internal a.c. voltage circuit to supply the rectifier stack. This internal a.c. voltage exceeds the d.c. voltage for physical reasons. This internal a.c. circuit is not to be considered as a higher voltage circuit within the meaning of this clause. Between internal circuits and external higher voltage circuits, protective separation is required.

NOTE 3 In d.c. systems with batteries, the battery charging and floating voltages exceed the battery nominal voltage, depending on the type of battery. This does not require any protective provisions in addition to those specified in this clause. The charging voltage should not exceed a maximum value of 75 V a.c. or 150 V d.c. as appropriate according to the environmental situation as given in Table 1 of IEC 61201:1992.

414.3 Sources for SELV and PELV

The following sources may be used for SELV and PELV systems:

414.3.1 A safety isolating transformer in accordance with IEC 61558-2-6.

414.3.2 A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified in 414.3.1 (e.g. motor generator with windings providing equivalent isolation).

414.3.3 An electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator).

414.3.4 Certain electronic devices complying with appropriate standards where provisions have been taken in order to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in 414.1.1. Higher voltages at the outgoing terminals are, however, permitted if it is ensured that, in case of contact with a live part or in the event of a fault between a live part and an exposed-conductive-part, the voltage at the output terminals is immediately reduced to those values or less.

NOTE 1 Examples of such devices include insulation testing equipment and monitoring devices.

NOTE 2 Where higher voltages exist at the outgoing terminals, compliance with this clause may be assumed if the voltage at the outgoing terminals is within the limits specified in 414.1.1 when measured with a voltmeter having an internal resistance of at least 3 000 Ω.

414.3.5 Mobile sources supplied at low voltage, e.g. safety isolating transformers or motor generators, shall be selected or erected in accordance with the requirements for protection by the use of double or reinforced insulation (see Clause 412).

414.4 Requirements for SELV and PELV circuits

414.4.1 SELV and PELV circuits shall have

– basic insulation between live parts and other SELV or PELV circuits, and
– protective separation from live parts of circuits not being SELV or PELV, provided by double or reinforced insulation or by basic insulation and protective screening for the highest voltage present.

SELV circuits shall have basic insulation between live parts and earth.

The PELV circuits and/or exposed-conductive-parts of equipment supplied by the PELV circuits may be earthed.

NOTE 1 In particular, protective separation is necessary between the live parts of electrical equipment such as relays, contactors, auxiliary switches, and any part of a higher voltage circuit or a FELV circuit.

NOTE 2 The earthing of PELV circuits may be achieved by a connection to earth or to an earthed protective conductor within the source itself.

414.4.2 Protective separation of wiring systems of SELV and PELV circuits from the live parts of other circuits, which have at least basic insulation, may be achieved by one of the following arrangements:

– SELV and PELV circuit conductors shall be enclosed in a non-metallic sheath or insulating enclosure in addition to basic insulation;
– SELV and PELV circuit conductors shall be separated from conductors of circuits at voltages higher than Band I by an earthed metallic sheath or earthed metallic screen;
– circuit conductors at voltages higher than Band I may be contained in a multi-conductor cable or other grouping of conductors if the SELV and PELV conductors are insulated for the highest voltage present;
– the wiring systems of other circuits are in compliance with 412.2.4.1;
– physical separation.

414.4.3 Plugs and socket-outlets in SELV and PELV systems shall comply with the following requirements:

– plugs shall not be able to enter socket-outlets of other voltage systems;
– socket-outlets shall not admit plugs of other voltage systems;
– plugs and socket-outlets in SELV systems shall not have a protective conductor contact.

414.4.4 Exposed-conductive-parts of SELV circuits shall not be connected to earth, or to protective conductors or exposed-conductive-parts of another circuit.

NOTE If the exposed-conductive-parts of SELV circuits are liable to come into contact, either fortuitously or intentionally, with the exposed-conductive-parts of other circuits, protection against electric shock no longer depends solely on protection by SELV, but also on the protective provisions to which the latter exposed-conductive-parts are subject.

414.4.5 If the nominal voltage exceeds 25 V a.c. or 60 V d.c. or if the equipment is immersed, basic protection shall be provided for SELV and PELV circuits by:

– insulation in accordance with Clause A.1, or
– barriers or enclosures in accordance with Clause A.2.

Basic protection is generally unnecessary in normal dry conditions for

– SELV circuits where the nominal voltage does not exceed 25 V a.c. or 60 V d.c.;
– PELV circuits where the nominal voltage does not exceed 25 V a.c. or 60 V d.c. and exposed-conductive-parts and/or the live parts are connected by a protective conductor to the main earthing terminal.

In all other cases, basic protection is not required if the nominal voltage of the SELV or PELV system does not exceed 12 V a.c. or 30 V d.c.

415 Additional protection

NOTE Additional protection may be specified with the protective measure under certain conditions of external influence and in certain special locations (see the corresponding Part 7 of IEC 60364).

415.1 Additional protection: residual current protective devices (RCDs)

415.1.1 The use of RCDs with a rated residual operating current not exceeding 30 mA, is recognized in a.c. systems as additional protection in the event of failure of the provision for basic protection and/or the provision for fault protection or carelessness by users.

NOTE In Hungary RCDs with rated operating current not exceeding 100 mA can be used as additional protection in installations situated outside.

415.1.2 The use of such devices is not recognized as a sole means of protection and does not obviate the need to apply one of the protective measures specified in Clause 411 to Clause 414.

415.2 Additional protection: supplementary protective equipotential bonding

NOTE 1 Supplementary protective equipotential bonding is considered as an addition to fault protection.

NOTE 2 The use of supplementary protective bonding does not exclude the need to disconnect the supply for other reasons, for example protection against fire, thermal stresses in equipment, etc.

NOTE 3 Supplementary protective bonding may involve the entire installation, a part of the installation, an item of apparatus, or a location.

NOTE 4 Additional requirements may be necessary for special locations, (see the corresponding Part 7 of IEC 60364), or for other reasons.

415.2.1 Supplementary protective equipotential bonding shall include all simultaneously accessible exposed-conductive-parts of fixed equipment and extraneous-conductive-parts including where practicable the main metallic reinforcement of constructional reinforced concrete. The equipotential bonding system shall be connected to the protective conductors of all equipment including those of socket-outlets.

415.2.2 Where doubt exists regarding the effectiveness of supplementary protective equipotential bonding, it shall be confirmed that the resistance R between simultaneously accessible exposed-conductive-parts and extraneous-conductive-parts fulfils the following condition:

$$R \leq \frac{50\ \text{V}}{I_\text{a}} \text{ in a.c. systems}$$

$$R \leq \frac{120\ \text{V}}{I_\text{a}} \text{ in d.c. systems}$$

where

I_a is the operating current in A of the protective device

– for residual current protective devices (RCDs), $I_{\Delta\text{n}}$

– for overcurrent devices, the 5 s operating current.

Annex A
(normative)

Provisions for basic protection

NOTE Provisions for basic protection provide protection under normal conditions and are applied where specified as a part of the chosen protective measure.

A.1 Basic insulation of live parts

NOTE The insulation is intended to prevent contact with live parts.

Live parts shall be completely covered with insulation which can only be removed by destruction.

For equipment, the insulation shall comply with the relevant standard for the electrical equipment.

A.2 Barriers or enclosures

NOTE Barriers or enclosures are intended to prevent contact with live parts.

A.2.1 Live parts shall be inside enclosures or behind barriers providing at least the degree of protection IPXXB or IP2X except that, where larger openings occur during the replacement of parts, such as certain lampholders or fuses, or where larger openings are necessary to allow the proper functioning of equipment according to the relevant requirements for the equipment:

– suitable precautions shall be taken to prevent persons or livestock from unintentionally touching live parts, and
– it shall be ensured, as far as practicable, that persons will be aware that live parts can be touched through the opening and should not be touched intentionally, and
– the opening shall be as small as is consistent with the requirement for proper functioning and for replacement of a part.

A.2.2 Horizontal top surfaces of barriers or enclosures which are readily accessible shall provide a degree of protection of at least IPXXD or IP4X.

A.2.3 Barriers and enclosures shall be firmly secured in place and have sufficient stability and durability to maintain the required degrees of protection and appropriate separation from live parts in the known conditions of normal service, taking account of relevant external influences.

A.2.4 Where it is necessary to remove barriers or open enclosures or to remove parts of enclosures, this shall be possible only

– by the use of a key or tool, or
– after disconnection of the supply to live parts against which the barriers or enclosures afford protection, restoration of the supply being possible only after replacement or reclosure of the barriers or enclosures, or
– where an intermediate barrier providing a degree of protection of at least IPXXB or IP2X prevents contact with live parts, by the use of a key or tool to remove the intermediate barrier.

A.2.5 If, behind a barrier or in an enclosure, items of equipment are installed which may retain dangerous electrical charges after they have been switched off (capacitors, etc.), a warning label is required. Small capacitors such as those used for arc extinction, for delaying the response of relays, etc shall not be considered dangerous.

NOTE Unintentional contact is not considered dangerous if the voltage resulting from static charges fall below 120 V d.c. in less than 5 s after disconnection from the power supply.

Annex B
(normative)

Obstacles and placing out of reach

B.1 Application

The protective measures of obstacles and placing out of reach provide basic protection only. They are for application in installations with or without fault protection that are controlled or supervised by skilled or instructed persons

The conditions of supervision under which the basic protective provisions of Annex B may be applied as part of the protective measure are given in 410.3.5.

B.2 Obstacles

NOTE Obstacles are intended to prevent unintentional contact with live parts but not intentional contact by deliberate circumvention of the obstacle.

B.2.1 Obstacles shall prevent

– unintentional bodily approach to live parts, and
– unintentional contact with live parts during the operation of live equipment in normal service.

B2.2 Obstacles may be removed without using a key or tool but shall be secured so as to prevent unintentional removal.

B.3 Placing out of reach

NOTE Protection by placing out of reach is intended only to prevent unintentional contact with live parts.

B.3.1 Simultaneously accessible parts at different potentials shall not be within arm's reach.

NOTE Two parts are deemed to be simultaneously accessible if they are not more than 2,50 m apart (see Figure B.1).

B.3.2 If a normally occupied position is restricted in the horizontal direction by an obstacle (e g. handrail, mesh screen) affording a degree of protection less than IPXXB or IP2X, arm's reach shall extend from that obstacle. In the overhead direction, arm's reach is 2,50 m from the surface, *S*, not taking into account any intermediate obstacle providing a degree of protection less than IPXXB.

NOTE The values of arm's reach apply to contact directly with bare hands without assistance (e.g. tools or ladder).

B.3.3 In places where bulky or long conductive objects are normally handled, the distances required by B.3.1 and B.3.2 shall be increased, taking account of the relevant dimensions of those objects.

Dimensions in metres

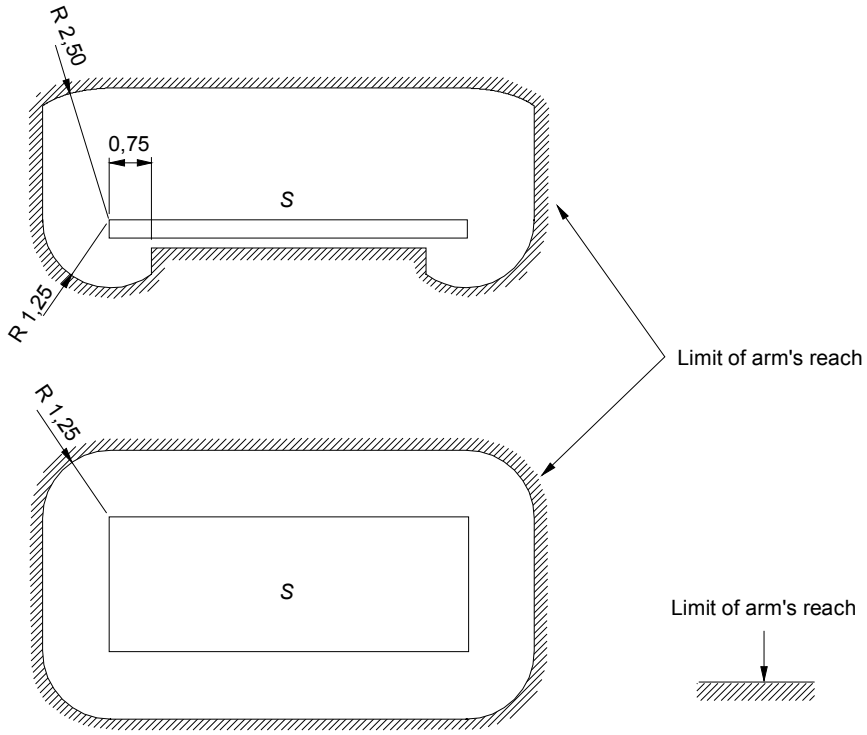

Figure B.1 – Zone of arm's reach

Annex C
(normative)

Protective measures for application only when the installation is controlled or under the supervision of skilled or instructed persons

NOTE The conditions of supervision under which the fault protective provisions (protection against indirect contact) of Annex C may be applied as part of the protective measure are given in 410.3.6.

C.1 Non-conducting location

NOTE 1 This protective measure is intended to prevent simultaneous contact with parts which may be at different potential through failure of the basic insulation of live parts.

NOTE 2 In Sweden protection by means of non-conducting location is not permitted.

C.1.1 All electrical equipment shall comply with one of the provisions for basic protection described in Annex A.

C.1.2 Exposed-conductive-parts shall be arranged so that under ordinary circumstances persons will not come into simultaneous contact with

– two exposed-conductive-parts, or
– an exposed-conductive-part and any extraneous-conductive-part,

if these parts are liable to be at different potential through failure of the basic insulation of live parts.

C.1.3 In a non-conducting location there shall be no protective conductor.

C.1.4 Subclause C.1.2 is fulfilled if the location has an insulating floor and walls and one or more of the following arrangements applies:

a) Relative spacing of exposed-conductive-parts and of extraneous-conductive-parts as well as spacing of exposed-conductive-parts.

   This spacing is sufficient if the distance between two parts is not less than 2,5 m; this distance may be reduced to 1,25 m outside the zone of arm's reach.

b) Interposition of effective obstacles between exposed-conductive-parts and extraneous-conductive-parts.

   Such obstacles are sufficiently effective if they extend the distances to be surmounted to the values stated in point a) above. They shall not be connected to earth or to exposed-conductive-parts; as far as possible they shall be of insulating material.

c) Insulation or insulating arrangements of extraneous-conductive-parts.

   The insulation shall be of sufficient mechanical strength and be able to withstand a test voltage of at least 2 000 V. Leakage current shall not exceed 1 mA in normal conditions of use.

C.1.5 The resistance of insulating floors and walls at every point of measurement under the conditions specified in IEC 60364-6 shall be not less than

– 50 kΩ, where the nominal voltage of the installation does not exceed 500 V, or

– 100 kΩ, where the nominal voltage of the installation exceeds 500 V.

NOTE If at any point the resistance is less than the specified value, the floors and walls are deemed to be extraneous-conductive-parts for the purposes of protection against shock.

C.1.6 The arrangements made shall be permanent and it shall not be possible to make them ineffective. They shall also ensure protection where the use of mobile or portable equipment is envisaged.

NOTE 1 Attention is drawn to the risk that, where electrical installations are not under effective supervision, further conductive parts may be introduced at a later date (e.g. mobile or portable Class I equipment or extraneous-conductive-parts such as metallic water pipes), which may invalidate compliance with C.1.6.

NOTE 2 It is essential to ensure that the insulation of floor and walls cannot be affected by humidity.

C.1.7 Precautions shall be taken to ensure that extraneous-conductive-parts cannot cause a potential to appear externally to the location concerned.

C.2 Protection by earth-free local equipotential bonding

NOTE Earth-free local equipotential bonding is intended to prevent the appearance of a dangerous touch voltage.

C.2.1 All electrical equipment shall comply with one of the provisions for basic protection (protection against direct contact) described in Annex A.

C.2.2 Equipotential bonding conductors shall interconnect all simultaneously accessible exposed-conductive-parts and extraneous-conductive-parts.

C.2.3 The local equipotential bonding system shall not be in electrical contact with earth directly, nor through exposed-conductive-parts, nor through extraneous-conductive-parts.

NOTE Where this requirement cannot be fulfilled, protection by automatic disconnection of supply is applicable (see Clause 411).

C.2.4 Precautions shall be taken to ensure that persons entering the equipotential location cannot be exposed to a dangerous potential difference, in particular, where a conductive floor insulated from earth is connected to the earth-free equipotential bonding system.

C.3 Electrical separation for the supply of more than one item of current-using equipment

NOTE Electrical separation of an individual circuit is intended to prevent shock currents through contact with exposed-conductive-parts that may be energized by a fault in the basic insulation of the circuit.

C.3.1 All electrical equipment shall comply with one of the provisions for basic protection described in Annex A.

C.3.2 Protection by electrical separation for the supply of more than one item of apparatus shall be ensured by compliance with all the requirements of Clause 413 except 413.1.2, and with the following requirements.

C.3.3 Precautions shall be taken to protect the separated circuit from damage and insulation failure.

C.3.4 The exposed-conductive-parts of the separated circuit shall be connected together by insulated, non-earthed equipotential bonding conductors. Such conductors shall not be connected to the protective conductors or exposed-conductive-parts of other circuits or to any extraneous-conductive-parts.

NOTE See Note to 413.3.6.

C.3.5 All socket-outlets shall be provided with protective contacts which shall be connected to the equipotential bonding system provided in accordance with C.3.4.

C.3.6 Except where supplying equipment with double or reinforced insulation, all flexible cables shall embody a protective conductor for use as an equipotential bonding conductor in accordance with C.3.4.

C.3.7 It shall be ensured that if two faults affecting two exposed-conductive-parts occur and these are fed by conductors of different polarity, a protective device shall disconnect the supply in a disconnecting time conforming with Table 41.1

C.3.8 It is recommended that the product of the nominal voltage of the circuit in volts and length, in metres, of the wiring system should not exceed 100 000 V/m, and that the length of the wiring system should not exceed 500 m.

Annex D
(informative)

Correspondence between IEC 60364-4-41:2001 and the present standard

The following table provides a list of contents of both the previous edition and the current edition of IEC 60364-4-41, indicating the changes that have occurred.

Table D.1 – Correspondence between IEC 60364-4-41:2001 and the present standard

IEC 60364-4-41:2001	Present standard
TITLE **Electrical installations of buildings –** **Part 4-41: Protection for safety –** **Protection against electric shock**	**Low-voltage electrical installations –** **Part 4-41: Protection for safety –** **Protection against electric shock**
410 Introduction	**410 Introduction**
410.1 Scope	**410.1 Scope**
410.2 Normative references	**410.2 Normative references**
410.3 Application of measures of protection against electric shock 410.3.1 General 410.3.2 Application of measures of protection against direct contact 410.3.3 Application of measures of protection against indirect contact 410.3.4 Application of measures of protection in relation to external influences	**410.3 General requirements**
411 Protection against both direct and indirect contact	**414 Protective measure: extra-low-voltage provided by SELV and PELV**
411.1 SELV and PELV 411.1.1 411.1.2 Sources for SELV and PELV 411.1.3 Arrangements of circuits 411.1.4 Requirements for unearthed circuits (SELV) 411.1.5 Requirements for earthed circuits (PELV)	414.1 General 414.3 Sources for SELV and PELV 414.4 Requirements for SELV and PELV circuits
411.2 Protection by limitation of energy (no requirements)	Not covered
411.3 FELV system 411.3.1 General 411.3.2 Protection against direct contact 411.3.3 Protection against indirect contact 411.3.4 Plugs and socket-outlets	**411.7 Functional extra-low voltage (FELV)** 411.7.1 General 411.7.2 Requirements for basic protection 411.7.3 Requirements for fault protection 411.7.5 Plugs and socket-outlets
412 Protection against direct contact	
412.1 Insulation of live parts	**Annex A, Clause A.1 Basic insulation of live parts**
412.2 Barriers or enclosures	**Annex A, Clause A.2 Barriers or enclosures**
412.3 Obstacles	**Annex B, Clause B.2 Obstacles**
412.4 Placing out of reach	**Annex B, Clause B.3 Placing out of reach**
412.5 Additional protection by residual current devices	**415.1 Additional protection: residual current protective devices (RCDs)**

Table D.1 *(continued)*

IEC 60364-4-41:2001	Present standard
413 Protection against indirect contact	
413.1 Automatic disconnection of supply 413.1.1 General 413.1.1.1 Disconnection of supply 413.1.1.2 Earthing 413.1.2 Equipotential bonding 413.1.2.1 Main equipotential bonding 413.1.2.2 Supplementary equipotential bonding 413.1.3 TN systems 413.1.4 TT systems 413.1.5 IT systems 413.1.6 Supplementary equipotential bonding 413.1.7 Requirements related to conditions of external influence	**411 Protective measure: automatic disconnection of supply** 411.3.2 Automatic disconnection in case of a fault 411.3.1.1 Protective earthing 411.3.1 Main protective earthing and equipotential bonding 411.3.1.2 Protective equipotential bonding 411.3.2.6 Supplementary equipotential bonding 411.4 TN systems 411.5 TT systems 411.6 IT systems 415.2 Additional protection: supplementary protective equipotential bonding No requirement
413.2 Class II equipment or equivalent insulation	**412 Protective measure: double or reinforced insulation**
413.3 Non-conducting location	**Annex C, Clause C.1 Non-conducting location**
413.4 Protection by earth-free local equipotential bonding	**Annex C, Clause C.2 Protection by earth-free local equipotential bonding**
413.5 Electrical separation	**413 Protective measure: electrical separation** **Annex C, Clause C.3 Electrical separation for the supply of more than one item of current-using equipment**

Bibliography

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IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53:Selection and erection of electrical equipment – Isolation, switching and control*

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IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

IEC 61008-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 61201:1992, *Extra-low voltage (ELV)– Limit values*

IEC 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

IEC 61557-9, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault location in IT systems*

IEC 62020, *Electrical accessories – Residual current monitors for household and similar uses (RCMs)*

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