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English version

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

(IEC 60364-4-41:2005, modified)

Installations électriques à basse tension – Partie 4-41: Protection pour assurer la sécurité - Protection contre les chocs électriques (CEI 60364-4-41:2005, modifiée)

Errichten von Niederspannungsanlagen – Teil 4-41: Schutzmaßnahmen - Schutz gegen elektrischen Schlag (IEC 60364-4-41:2005, modifiziert)

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This Harmonization Document exists in three official versions (English, French, German).

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 64/1489/FDIS, future edition 5 of IEC 60364-4-41, prepared by IEC TC 64, Electrical installations and protection against electric shock, was submitted to the IEC-CENELEC parallel vote.

A draft amendment, prepared by SC 64A, Protection against electric shock, of Technical Committee CENELEC TC 64, Electrical installations and protection against electric shock, was submitted to the formal vote.

The combined texts were approved by CENELEC as HD 60364-4-41 on 2006-02-01.

This Harmonization Document supersedes HD 384.4.41 S2:1996 + A1:2002, HD 384.4.46 S2:2001 and HD 384.4.47 S2:1995.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level (doa) 2006-08-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 2007-08-01
- latest date by which the national standards conflicting with the HD have to be withdrawn (dow) 2009-02-01

Annexes ZA and ZB have been added by CENELEC.

In this document, the common modifications to the International Standard are indicated by a vertical line in the left margin of the text.

Contents

410 Introduction

This Part 4-41 of HD 60364 deals with protection against electric shock as applied to electrical installations. It is based on EN 61140 which is a basic safety standard that applies to the protection of persons and livestock. EN 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 EN 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 EN 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 in accordance with IEC Guide 104 has the status of a group safety publication (GSP) for protection against electric shock.

In the previous edition HD 384.4.41 S2:1996

– 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.

410.1 Scope

Part 4-41 of HD 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*

HD 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 60364-5-54, modified)

HD 60364-6, *Low-voltage electrical installations – Part 6: Verification* (IEC 60364-6, modified)

EN 60439-1, *Low-voltage switchgear and controlgear assemblies* (IEC 60439-1)

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*

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

EN 61386 (all parts), *Conduit systems for cable management* (IEC 61386 – all parts)

EN 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 61558-2-6)

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

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 HD 60364 or HD 384).

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 HD 60364 or HD 384 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 This exemption applies, for example, to bolts, rivets, nameplates and cable clips.

– 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 (protection against direct contact)

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 (protection against indirect contact)

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 HD 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, where the reinforcements are accessible and reliably interconnected.

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 HD 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 HD 60364 or HD 384.

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.

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

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).								

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 the applicable time value of Table 41.1 or 5 s (as appropriate) 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 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.

– 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 Examples of conditions are:

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

– $R_B/R_E \leq 50\ V/(U_o - 50\ V)$.

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.

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 HD 60364-5-54 are satisfied. No switching or isolating device shall be inserted in the PEN conductor.

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.

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

NOTE 1 Where an RCD is used for fault protection (protection against indirect contact) 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.

411.5.3 Where a residual current protective device (RCD) is used for fault protection (protection against indirect contact) 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 in A of the RCD in A.

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 overcurrent 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 in V.

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 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.

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

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:

$$R_A \times I_a \leq 50\ V$$

where:

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

I_a is the current in A 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 (protection against direct contact) and fault protection (protection against indirect contact). 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 (protection against direct contact)

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 (protection against indirect contact)

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 HD 60364 or HD 384.

412.1.3 Where this protective measure is to be used as the sole protective measure (i.e. where a circuit or part of an installation is intended to consist entirely of equipment with double insulation or reinforced insulation), it shall be verified that the circuit or part of the installation 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 (protection against direct contact) and fault protection (protection against indirect contact)

412.2.1 Electrical equipment

Where the protective measure 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 EN 60439-1).

NOTE This equipment is identified by the symbol  reference IEC 60417-5172: 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: 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: 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.

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.

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