

# **Requirements for electrical installations**

Part 4:

**Protection for safety**

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# Requirements for electrical installations

Part 4:

## Protection for safety

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## Foreword

This Kenya Standard was prepared by the **Electrical Installations and Distribution Systems** Technical Committee under the guidance of the Standards Projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards.

Kenya Bureau of Standards (KEBS) has established Technical Committees (TCs) mandated to develop Kenya Standards (KS). The Committees are composed of representatives from the public and private sector organizations in Kenya.

Kenya Standards are developed through Technical Committees that are representative of key stakeholders including government, academia, consumer groups, private sector and other interested parties. Draft Kenya Standards are circulated to stakeholders through the KEBS website and notifications to World Trade Organization (WTO). The comments received are discussed and incorporated before finalization of the standards, in accordance with the Procedures for Development of Kenya Standards.

Kenya Standards are subject to review, to keep pace with technological advances. Users of the Kenya Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

This **third** edition cancels and replaces the **second** edition (KS 662-4:2000), which has been technically revised.

The revision of this standard is based on BS 7671 18<sup>th</sup> Edition with its several amendments and the different parts of IEC 60364 and is split into the following parts:

Part 1, Scope, object and fundamental

principles. Part 2. Definitions.

Part 3. Assessment of general

characteristics. Part 4: Protection for safety.

Part 5. Selection and erection of electrical equipment.

Part 6. Verification.

Part 7. Requirements for special installations or locations.

These parts are in line with those of IEC 60364 and they also match the chapters and sections of BS 7671:2018.

During the preparation of this standard, reference was made to the following documents:

IEC 60364 (All parts): Low-voltage installations.

BS 7671 (18th Edition) Requirements for electrical installations.

Acknowledgement is hereby made for the assistance derived from these sources.

## NOTES ON THE PLAN OF THIS EDITION

The edition is based on the plan agreed internationally for the arrangement of safety rules for electrical installations.

In the numbering system used, the first digit signifies a Part, the second digit a Chapter, the third digit a Section and the subsequent digits the standard number. For example, Section number 413 is made up as follows:

### PART 4- PROTECTION FOR SAFETY

Chapter 41 (first chapter of Part 4) - PROTECTION AGAINST ELECTRIC SHOCK.

Section 413 (third section of Chapter 41) - PROTECTIVE MEASURE: ELECTRICAL SEPARATION

Part 1 sets out the scope, object and fundamental principles.

Part 2 defines the sense in which certain terms are used throughout the Regulations, and provides a list of symbols used.

The subjects of the subsequent parts are as indicated below:

Part	Subject
Part 3	Identification of the characteristics of the installation that will need to be taken into account in choosing and applying the requirements of the subsequent Parts. These characteristics may vary from one part of an installation to another and should be assessed for each location to be served by the installation.
Part 4	Description of the measures that are available for the protection of persons, livestock and property, and against the hazards that may arise from the use of electricity.
Part 5	Precautions to be taken in the selection and erection of the equipment of the installation.
Part 6	Inspection and testing.
Part 7	Special installations or locations- particular requirements.

The sequence of the plan should be followed in considering the application of any particular requirement of the standard. The general index provides a ready reference to particular standard by subject, but in applying any one standard the requirements of related standards should be borne in mind. Cross references are provided, and the index is arranged to facilitate this.

In many cases, a group of associated clauses is covered by a side heading which is identified by a two-part number, e.g. 544.2. Throughout the standard where reference is made to such a two-part number, that reference is to be taken to include all the individual regulation numbers which are covered by that side heading and include that two-part number.

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# CHAPTER 41

## PROTECTION AGAINST ELECTRIC SHOCK

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## **400.1 Introduction**

**400.1.1** Chapters 41 to 46 specify essential requirements for protection of persons, animals and property. Chapter 47 deals with the application and co-ordination of these requirements and Chapter 48 qualifies those requirements in relation to particular classes of external influences. Requirements for the selection and erection of equipment are specified in KS 662-5 and test requirements in KS 662-6.

**400.1.2** Protective measures may be applicable to an entire installation, to a part, or to an item of equipment.

If certain conditions of a protective measure are not satisfied, supplementary measures shall be taken to ensure by such combined protective measures the same degree of safety as complete compliance with those conditions.

NOTE - An example of the application of this rule is given in **411.3**

**400.1.3** The order in which the protective measures are specified does not imply any relative importance.

## **400.2 Normative references**

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part 4 of this standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

*IEC 60146-2, Semiconductor convertors – Part 2: Semiconductor self commutated convertors*

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

*KS 662-1, Requirements for Electrical installations - Part 1: Scope, object and fundamental principles*

*KS 662-5, Requirements for Electrical installations - Part 5: Selection and erection of electrical equipment.*

*KS 662-7, Requirements for Electrical installations - Part 7., Requirements for special installations or locations*

*KS IEC 60479-1, Effects of current on human beings and livestock - Part 1: General aspects*

*KS IEC 60479-2, Effects of current on human beings and livestock - Part 2: Special aspects*

*IEC 60038, IEC standard voltages*

*IEC 60050(826), International Electrotechnical Vocabulary (IEV) - Chapter 826: Electrical installations of buildings*

*IEC 60664-1, Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests*

*IEC 61024-1, Protection of structures against lightning - Part 1: General principles*

*KS IEC 61439-3, Low-voltage switchgear and controlgear-Part 3: Distribution boards intended to be operated by ordinary persons (DBO)*

*IEC 60417, Graphical Symbols for Use on Equipment*

*IEC 60947-2, Low-voltage switchgear and controlgear - Part 2: Circuit-breakers*

*KS KS KS IEC 60947-4-1, Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters*

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

*IEC 61558, Safety of transformers, reactors, power supply units and combinations thereof - Requirements*

*IEC TR 61000-2-5, Electromagnetic compatibility (EMC) - Part 2-5: Environment - Description and classification of electromagnetic environments*

*IEC 61000-4-5, Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test*

*IEC 61000-6-3, Electromagnetic compatibility (EMC) - Part 6-3: Generic standards*

*IEC 62305-4, Protection against lightning - Part 4: Electrical and electronic systems within structures*

# CHAPTER 41

## PROTECTION AGAINST ELECTRIC SHOCK

### 410 INTRODUCTION

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

The fundamental rule of protection against electric shock, according to KS IEC 61140, is that hazardous-live -parts shall not be accessible and accessible conductive parts shall not be hazardous-live, both under normal conditions and 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.

#### 410.1 Scope

Chapter 41 specifies essential requirements regarding protection against electric shock, including basic protection and fault protection of persons and livestock. It deals also with the application and co-ordination of these requirements in relation to external influences.

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

#### 410.2 Not used

#### 410.3 General requirements

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

- AC voltages are rms
- DC voltages are ripple-free.

Ripple-free is conventionally defined as an rms ripple voltage of not more than 10 % of the DC component.

410.3.2 A protective measure shall consist of:

- (i) an appropriate combination of a provision for basic protection and an independent provision for fault protection, or
- (ii) 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 influence and in certain special locations (see the corresponding sections of Part 7).

**NOTE 1:** For special applications, protective measures which do not follow this concept are permitted (see s 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:

- (i) automatic disconnection of supply (Section 411)
- (ii) double or reinforced insulation (Section 412)
- (iii) electrical separation for the supply to one item of current-using equipment (Section 413)
- (iv) extra-low voltage (SELV and PELV) (Section 414).

The protective measures applied in the installation shall be considered in the selection and erection of equipment. For particular installations see s 410.3.4 to 410.3.9.

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

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

**410.3.5** The protective measures specified in Section 417, i.e. the use of obstacles and placing out of reach, shall only be used in installations restricted to:

- (i) skilled persons, or
- (ii) instructed persons under the supervision of skilled persons.

**410.3.6** The protective measures specified in Section 418, i.e.

- (i) non-conducting location
- (ii) earth-free local equipotential bonding
- (iii) electrical separation for the supply of more than one item of current-using equipment

shall be applied only where 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 is given in 411.7 (FELV).

**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 measure or measures.

**410.3.9** The provision for fault protection may be omitted for the following equipment:

- (i) metal supports of overhead line insulators which are attached to the building and are placed out of arm's reach
- (ii) steel reinforced concrete poles of overhead lines in which the steel reinforcement is not accessible
- (iii) exposed-conductive-parts which, owing to their reduced dimensions (approximate maximum of 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, cable clips, screws and other fixings.

- (iv) metal enclosures protecting equipment in accordance with Section 412
- (v) unearthed street furniture supplied from an overhead line and inaccessible in normal use.

## **411 PROTECTIVE MEASURE: AUTOMATIC DISCONNECTION OF SUPPLY**

### **411.1 General**

Automatic disconnection of supply is a protective measure in which:

- (i) basic protection is provided by basic insulation of live parts or by barriers or enclosures, in accordance with Section 416, and
- (ii) fault protection is provided by protective earthing, protective equipotential bonding and automatic disconnection in case of a fault, in accordance with 411.3 to 411.6.

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

Where specified, additional protection is provided by an RCD with rated residual operating current not exceeding 30 mA, in accordance with 415.1.

**NOTE:** Residual Current Monitors (RCMs) are not protective devices but they may be used to monitor residual currents in an electrical installation. RCMs produce an audible or audible and visual signal when a preselected value of residual current is reached.

### **411.2 Requirements for basic protection**

All electrical equipment shall comply with one of the provisions for basic protection described in Section 416 or, where appropriate, Section 417.

### **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 Chapter 54.

A circuit protective conductor shall be run to and terminated at each point in wiring and at each accessory except a lampholder having no exposed-conductive-parts and suspended from such a point.

##### **411.3.1.2 Protective equipotential bonding**

In each installation main protective bonding conductors complying with Chapter 54 shall connect to the main earthing terminal extraneous-conductive-parts including the following:

- (i) Water installation pipes
- (ii) Gas installation pipes
- (iii) Other installation pipework and ducting
- (iv) Central heating and air conditioning systems
- (v) Exposed metallic structural parts of the building.

Metallic pipes entering the building having an insulating section at their point of entry need not be connected to the protective equipotential bonding.

Connection of a lightning protection system to the protective equipotential bonding shall be made in accordance with IEC 62305.

Where an installation serves more than one building the above requirement shall be applied to each building.

To comply with the requirements of these s it is also necessary to apply equipotential bonding to any metallic sheath of a telecommunication cable. However, the consent of the owner or operator of the cable shall be obtained.

#### **411.3.2 Automatic disconnection in case of a fault**

**411.3.2.1** Except as provided by 411.3.2.5, 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 by 411.3.2.2, 411.3.2.3 or 411.3.2.4.

The protective device shall be suitable for isolation of at least the line conductor.

**NOTE:** For IT systems, automatic disconnection is not necessarily required on the occurrence of a first fault (see 411.6.1). For the requirements for disconnection in the event of a second fault, occurring on a different live conductor, see 411.6.5.

**411.3.2.2** Maximum disconnection times stated in Table 41.1 shall be applied to final circuits with a rated current not exceeding:

- (i) 63 A with one or more socket-outlets, and
- (ii) 32 A supplying only fixed connected current-using equipment.

**TABLE 41.1 –  
Maximum disconnection times**

System	50 V < U <sub>0</sub> ≤ 120 V (s)		120 V < U <sub>0</sub> ≤ 230 V (s)		230 V < U <sub>0</sub> ≤ 400 V (s)		U <sub>0</sub> > 400 V (s)	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0.8	NOTE 1	0.4	1	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 in accordance with 411.3.1.2, the maximum disconnection times applicable to TN systems may be used.

U<sub>0</sub> nominal AC rms or ripple-free DC line voltage to Earth.

Where compliance with this is provided by an RCD, 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.

**NOTE 1:** Disconnection is not required for protection against electric shock but may be required for other reasons, such as protection against thermal effects.

**NOTE 2:** Where disconnection is provided by an RCD, see Note 2 to 411.4.4, Note 1 to 411.5.3 and Note 4 to 411.6.5.

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

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

**411.3.2.5** Where it is not feasible for an overcurrent protective device to interrupt the supply in accordance with 411.3.2 or the use of an RCD for this purpose is not appropriate, see Section 419. However, disconnection may be required for reasons other than protection against electric shock.

#### **411.3.3 Additional requirements for socket-outlets and for the supply of mobile equipment for use outdoors**

In AC systems, additional protection by means of an RCD with a rated residual operating current not exceeding 30 mA shall be provided for:

- (i) socket-outlets with a rated current not exceeding 32A, and
- (ii) mobile equipment with a rated current not exceeding 32A for use outdoors.

An exception to (i) is permitted where, other than for an installation in a dwelling, a documented risk assessment determines that RCD protection is not necessary.

The requirements of 411.3.3 do not apply to FELV systems according to 411.7 or reduced low voltage systems according to 411.8.

**NOTE 1:** See also 314.1(iv) and 531.3.2 concerning the avoidance of unwanted tripping.

**NOTE 2:** A lighting distribution unit complying with IEC 60670, luminaire track system, installation coupler, LSC or DCL is not regarded as a socket-outlet for the purposes of this .

#### **411.3.4 Additional requirements for circuits with luminaires**

Within domestic (household) premises, additional protection by an RCD with a rated residual operating current not exceeding 30 mA shall be provided for AC final circuits supplying luminaires.

### **411.4 TN system**

**411.4.1** In a TN system, 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 distributor.

**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:** The PE and PEN conductors may additionally be connected to Earth, such as at the point of entry into the building.

**411.4.3** In a fixed installation, a single conductor may serve both as a protective conductor and as a neutral conductor (PEN conductor) provided that the requirements of 543.4 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:

$$Z_s \times I_a \leq U_0 \times C_{min}$$

where:

$Z_s$  is the impedance in ohms ( $\Omega$ ) 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 an 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

$U_0$  nominal AC rms or ripple-free DC line voltage to Earth

$C_{min}$  is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

**NOTE:** For a low voltage supply given in accordance with the Electricity Safety, Quality and Continuity Regulations,  $C_{min}$  is given the value 0.95.

**NOTE 1:** Where compliance with this is provided by an RCD, 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.

**NOTE 2:** In TN systems the residual fault currents are significantly higher than  $5 I_{\Delta n}$ . Therefore, the disconnecting times in accordance with Table 41.1 are fulfilled where an RCD according to IEC 61008, IEC 61009 or IEC 62423 is used. A CBR according to IEC 60947-2 can be used, provided the time delay is adjusted to afford compliance with Table 41.1.

**411.4.5** The following types of protective device may be used for fault protection:

- (i) An overcurrent protective device
- (ii) An RCD.

Where an RCD is used for fault protection the circuit shall also incorporate an overcurrent protective device in accordance with Chapter 43.

An RCD shall not be used in a TN-C system.

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:** Where selectivity between RCDs is necessary, see 536.4.1.6.

**411.4.201** Where a fuse is used to satisfy the requirements of 411.3.2.2, maximum values of earth fault loop impedance ( $Z_s$ ) corresponding to a disconnection time of 0.4 s are stated in Table 41.2 for a nominal voltage ( $U_0$ ) of 230 V. For types and rated currents of general purpose (gG) and motor circuit application (gM) fuses other than those mentioned in Table 41.2, reference should be made to the appropriate Kenyan Standard to determine the value of  $I_a$  for compliance with 411.4.4.

**TABLE 41.2 –  
Maximum earth fault loop impedance ( $Z_s$ ) for fuses, for 0.4 s disconnection time with  $U_0$   
of 230 V (see 411.4.201)**

<b>(a) General purpose (gG) and motor circuit application (gM) fuses to KS IEC 60269-2-fuse systems E (bolted) and G (clip-in)</b>											
Rating (amperes)	2	4	6	10	16	20	25	32	40	50	63
$Z_s$ (ohms)	33.1	15.6	7.80	4.65	2.43	1.68	1.29	0.99	0.75	0.57	0.44
<b>(b) Fuses to KS IEC 60269 fuse system C</b>											
Rating (amperes)	5	16	20	32	45	63					
$Z_s$ (ohms)	9.93	2.30	1.93	0.91	0.57	0.36					
<b>(c) Fuses to KS IEC 60269-3 fuse system</b>							<b>(d) Fuses to KS IEC 60269</b>				
Rating (amperes)	5	15	20	30	45	60			Rating (amperes)	3	13
$Z_s$ (ohms)	9.10	2.43	1.68	1.04	0.56	0.40			$Z_s$ (ohms)	15.6	2.30

**NOTE 1:** The circuit loop impedances have been determined using a value for factor  $C_{min}$  of 0.95.

**NOTE 2:** The circuit loop impedances given in the table should not be exceeded when:

- (i) the line conductors are at the appropriate maximum permitted operating temperature, as given in Table 52.1, and
- (ii) the circuit protective conductors are at the appropriate assumed initial temperature, as given in Tables 54.2 to 54.5.

**NOTE 3:** Where the line conductor insulation is of a type for which Table 52.1 gives a maximum permitted operating temperature exceeding 70 °C, such as thermosetting, but the conductor has been sized in accordance with 512.1.5:

- (i) the maximum permitted operating temperature for the purpose of Note 2(i) is 70 °C, and
- (ii) the assumed initial temperature for the purpose of Note 2(i) is that given in Tables 54.2 to 54.4 corresponding to an insulation material of 70 °C thermoplastic.

**411.4.202** Where a circuit-breaker is used to satisfy the requirements of 411.3.2.2 or 411.3.2.3, the maximum value of earth fault loop impedance ( $Z_s$ ) shall be determined by the formula in 411.4.4. Alternatively, for a nominal voltage ( $U_0$ ) of 230 V and a disconnection time of 0.4 s in accordance with 411.3.2.2 or 5 s in accordance with 411.3.2.3, the values specified in Table 41.3 for the types and ratings of overcurrent devices listed may be used instead of calculation.

**Table 41.3 –  
Maximum earth fault loop impedance ( $Z_s$ ) for circuit breakers with  $U_0$  of 230V, for operation giving compliance with the 0.4 sec disconnection time of 411.3.2.2 and 5 sec disconnection of 411.3.2.3 (for RCBOs see also 411.4.204)**

<b>a) Type B circuit-breakers to KS IEC 60898 and the overcurrent characteristics of RCBOs to KS IEC 61009-1</b>														
Rating (amperes)	3	6	10	16	20	25	32	40	50	63	80	100	125	$I_n$
$Z_s$ (ohms)	14.57	7.28	4.37	2.73	2.19	1.75	1.37	1.09	0.87	0.69	0.55	0.44	0.35	$230 \times 0.95 / (5I_n)$
<b>b) Type C circuit-breakers to KS IEC 60898 and the overcurrent characteristics of RCBOs to KS IEC 61009-1</b>														
Rating (amperes)		6	10	16	20	25	32	40	50	63	80	100	125	$I_n$
$Z_s$ (ohms)		3.64	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	$230 \times 0.95 / (10I_n)$
<b>c) Type D circuit-breakers to KS IEC 60898 and the overcurrent characteristics of RCBOs to KS IEC 61009-1</b>														
Rating (amperes)		6	10	16	20	25	32	40	50	63	80	100	125	$I_n$
$Z_s$ (ohms) 0.4s		1.82	1.09	0.68	0.55	0.44	0.34	0.27	0.22	0.17	0.14	0.11	0.09	$230 \times 0.95 / (20I_n)$
$Z_s$ (ohms) 5s		3	2.19	1.37	1.09	0.87	0.68	0.55	0.44	0.35	0.27	0.22	0.17	$230 \times 0.95 / (10I_n)$

**NOTE 1:** The circuit loop impedances have been determined using a value for factor  $C_{min}$  of 0.95.

**NOTE 2:** The circuit loop impedances given in the table should not be exceeded when:

- (i) the line conductors are at the appropriate maximum permitted operating temperature, as given in Table 52.1, and
- (ii) the circuit protective conductors are at the appropriate assumed initial temperature, as given in Tables 54.2 to 54.5.

**NOTE 3:** Where the line conductor insulation is of a type for which Table 52.1 gives a maximum permitted operating temperature exceeding 70 °C, such as thermosetting, but the conductor has been sized in accordance with 512.1.5:

- (i) the maximum permitted operating temperature for the purpose of Note 2(i) is 70 °C, and
- (ii) the assumed initial temperature for the purpose of Note 2(i) is that given in Tables 54.2 to 54.4 corresponding to an insulation material of 70 °C thermoplastic.

**411.4.203** Where a fuse is used for a distribution circuit or a final circuit in accordance with 411.3.2.3, maximum values of earth fault loop impedance ( $Z_s$ ) corresponding to a disconnection time of 5 s are stated in Table 41.4 for a nominal voltage ( $U_0$ ) of 230 V. For types and rated currents of general purpose (gG) and motor circuit application (gM) fuses other than those mentioned in Table 41.4, reference should be made to the appropriate Kenyan Standard to determine the value of  $I_a$  for compliance with 411.4.4.

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**TABLE 41.4 –  
Maximum earth fault loop impedance ( $Z_s$ ) for fuses, for 5 s disconnection time with  $U_0$  of 230 V (see 411.4.203)**

<b>a) General purpose gG and motor circuit application gM fuses to KS IEC 60269-1-fuse systems E (bolted) and G (clip in)</b>								
Rating(amperes)	2	4	6	10	16	20	25	32
$Z_s$ (ohms)	44	21	12	6.8	4.0	2.8	2.2	1.7
Rating(amperes)	40	50	63	80	100	125	160	200
$Z_s$ (ohms)	1.3	0.99	0.78	0.55	0.42	0.32	0.27	0.18
<b>b) Fuses to KS IEC 60269-2 fuse system C</b>								
Rating(amperes)	5	16	20	32	45	63	80	100
$Z_s$ (ohms)	14.6	3.9	3.2	1.6	1.0	0.68	0.51	0.38
<b>c) Fuses to KS IEC 60269</b>								
Rating(amperes)	5	15	20	30	45	60	100	
$Z_s$ (ohms)	16.8	5.08	3.64	2.51	1.51	1.07	0.51	
<b>d) Fuses to KS IEC 60269</b>								
Rating(amperes)	3	13						
$Z_s$ (ohms)	22.0	3.64						

**NOTE 1:** The circuit loop impedances have been determined using a value for factor  $C_{min}$  of 0.95.

**NOTE 2:** The circuit loop impedances given in the table should not be exceeded when:

- (i) the line conductors are at the appropriate maximum permitted operating temperature, as given in Table 52.1, and
- (ii) the circuit protective conductors are at the appropriate assumed initial temperature, as given in Tables 54.2 to 54.4.

**NOTE 3:** Where the line conductor insulation is of a type for which Table 52.1 gives a maximum permitted operating temperature exceeding 70 °C, such as thermosetting, but the conductor has been sized in accordance with 512.1.5:

- (i) the maximum permitted operating temperature for the purpose of Note 2(i) is 70 °C, and
- (ii) the assumed initial temperature for the purpose of Note 2(i) is that given in Tables 54.2 to 54.5. corresponding to an insulation material of 70 °C thermoplastic.

**NOTE 4:** Data for fuses of rating exceeding 200 A should be obtained from the manufacturer.

**411.4.204** Where an RCD is used to satisfy the requirements of 411.3.2.2, 411.3.2.3 or 411.3.2.4 the maximum values of earth fault loop impedance in Table 41.5 may be applied for non-delayed RCDs to IEC 61008-1 and IEC 61009-1 for a nominal voltage  $U_0$  of 230 V. In such cases, an overcurrent protective device shall provide protection against overload current and fault current in accordance with Chapter 43.

## **411.5 TT system**

**411.5.1** Every exposed-conductive-part which is to be protected by a single protective device shall be connected, via the main earthing terminal, to a common earth electrode. However, if two or more protective devices are in series, the exposed-conductive-parts may be connected to separate earth electrodes corresponding to each protective device.

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.

**411.5.2** One or more of the following types of protective device shall be used, the former being preferred:

- (i) An RCD
- (ii) An overcurrent protective device.

**NOTE 1:** An appropriate overcurrent protective device may be used for fault protection provided a suitably low value of  $Z_s$  is permanently and reliably assured.

**NOTE 2:** Where an RCD is used for fault protection the circuit should also incorporate an overcurrent protective device in accordance with Chapter 43.

**411.5.3** Where an RCD is used for fault protection, the following conditions shall be fulfilled:

- (i) The disconnection time shall be that required by 411.3.2.2 or 411.3.2.4, and
- (ii)  $R_A \times I_{\Delta n} \leq 50 \text{ V}$

where:

$R_A$  is the sum of the resistances of the earth electrode and the protective conductor connecting it to the exposed-conductive-parts (in ohms)

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

The requirements of this are met if the earth fault loop impedance of the circuit protected by the RCD meets the requirements of Table 41.5.

**NOTE 1:** Where selectivity between RCDs is necessary refer also to 536.4.1.4.

**NOTE 2:** Where  $R_A$  is not known, it may be replaced by  $Z_s$ .

**TABLE 41.5 –**

**Maximum earth fault loop impedance ( $Z_s$ ) for non-delayed and time delayed 'S' Type RCDs to KS IEC 61008-1 and KS IEC 61009-1 for  $U_0$  of 230 V (see 411.5.3)**

Rated residual operating current (mA)	Maximum earth fault loop impedance $Z_s$ (ohms)
30	1667*
100	500*
300	167
500	100

Disconnection shall be within the times stated in Table 41.1.

**NOTE 1:** Figures for  $Z_s$  result from the application of 411.5.3(i) and (ii).

**NOTE 2:** \* The resistance of the installation earth electrode should be as low as practicable. A value exceeding 200 ohms may not be stable. Refer to 542.2.4.

**411.5.4** Where an overcurrent protective device is used the following condition shall be

fulfilled:  $Z_s \times I_a \leq U_0 \times C_{\min}$

where:

$Z_s$  is the impedance in ohms ( $\Omega$ ) of the earth fault loop comprising:

- the source
- the line conductor up to the point of the fault
- the protective conductor from 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 amperes (A) causing the automatic operation of the disconnecting device within the time specified in 411.3.2.2 or 411.3.2.4

$U_0$  nominal AC rms or ripple-free DC line voltage to Earth

$C_{\min}$  is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

amended,  $C_{\min}$  is given the value 0.95.

## 411.6 IT system

**411.6.1** In an IT system, 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 midpoint 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 midpoint exists, a line conductor may be connected to Earth through a high impedance.

Where the above conditions apply, the fault current is then low in the event of a single fault to an exposed-conductive-part or to Earth, so that automatic disconnection in accordance with 411.3.2 is not imperative provided that the condition in 411.6.2 is fulfilled. Precautions shall be taken, however, to avoid the risk of harmful effects on a person in contact with simultaneously accessible exposed-conductive-parts in the event of two faults existing simultaneously.

**NOTE 1:** It is strongly recommended that IT systems with distributed neutrals should not be employed.

**NOTE 2:** 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. In AC systems the following condition shall be fulfilled to limit the touch voltage to:

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

where:

$R_A$  is the sum of the resistances in ohms of the earth electrode and protective conductor for the exposed-conductive-parts.

$I_d$  is the fault current in amperes (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.

**NOTE:** No touch voltage limitation is considered in DC systems as the value of  $I_d$  can be considered to be negligibly low.

**411.6.3** The following monitoring devices and protective devices may be used:

- (i) insulation monitoring devices (IMDs)
- (ii) residual current monitoring devices (RCMs)
- (iii) insulation fault location systems (IFLS)
- (iv) overcurrent protective devices (OCPD)
- (v) residual current devices (RCDs).

**NOTE 1:** Where an RCD is used, tripping of the RCD in the event of a first fault cannot be excluded, due to capacitive leakage currents.

**NOTE 2:** In case of faults in two different Class I current-using devices supplied by different line conductors, the operation of an RCD is only likely to be achieved if every single item of current-using equipment is protected by an individual RCD. In such a case, the use of an overcurrent protective device is more suitable.

**411.6.4** Where an IT system is designed not to disconnect in the event of a first fault, the occurrence of the first fault shall be indicated by either:

- (i) an insulation monitoring device (IMD), which may be combined with an insulation fault location system (IFLS), or
- (ii) a residual current monitor (RCM), provided the residual current is sufficiently high to be detected.

**NOTE: R C M s** are not able to detect symmetrical insulation faults.

The device shall initiate an audible and/or visual signal which shall continue as long as the fault persists. The signal can be initiated via a relay contact output, an electronic switching output or a communication protocol.

A visual and/or an audible alarm system shall be arranged at a suitable place, so that it is perceived by responsible persons.

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

In addition, an insulation fault location system according to IEC 61557-9 may be provided to indicate the location of a first fault from a live part to exposed-conductive-parts or Earth or another reference point.

**411.6.5** 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:

- (i) 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 AC systems and in DC systems where the midpoint conductor is not distributed:

$$Z_s \leq \frac{U \times C_{min}}{2I_a}$$

or where the neutral conductor or midpoint conductor respectively is distributed:

$$Z_s^1 \leq \frac{U_0 \times C_{min}}{2I_a}$$

where:

- U is the nominal AC or DC voltage, in volts, between line conductors  
U<sub>0</sub> is the nominal AC or DC voltage, in volts, between line conductor and neutral conductor or midpoint conductor, as appropriate  
Z<sub>s</sub> is the impedance in ohms of the fault loop comprising the line conductor and the protective conductor of the circuit  
Z<sub>1s</sub> is the impedance in ohms of the fault loop comprising the neutral conductor and the protective conductor of the circuit  
I<sub>a</sub> is the current in amperes (A) causing operation of the protective device within the time required in 411.3.2.2 for TN systems or 411.3.2.3  
C<sub>min</sub> is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

**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 midpoint conductor.

**NOTE 2:** The factor 2 in both formulae 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 current-using equipment of the circuit considered.

- (ii) 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<sub>A</sub> is the sum of the resistances, in ohms, of the earth electrode and the protective conductor to the exposed-conductive-parts  
I<sub>a</sub> is the current in amperes causing automatic disconnection of the disconnection device in a time complying with that for TT systems in Table 41.1 of 411.3.2.2 or in a time complying with 411.3.2.4.

**NOTE 4:** If compliance to the requirements of (ii) is provided by an 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<sub>Δn</sub> of the RCD applied (typically 5 I<sub>Δn</sub>).

## **411.7 Functional extra-low voltage (FELV)**

### **411.7.1 General**

Where, for functional reasons, a nominal voltage not exceeding 50 V AC or 120 V DC is used but not all the requirements of Section 414 relating to SELV or to PELV are fulfilled, and where SELV or PELV is not necessary, the supplementary provisions described in 411.7.2 and 411.7.3 shall be applied to provide basic protection and fault protection.

This combination of provisions is known as FELV.

**NOTE:** Such conditions may, for example, be encountered where 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:

- (i) basic insulation according to 416.1 corresponding to the nominal voltage of the primary circuit of the source, or
- (ii) barriers or enclosures in accordance with 416.2.

### **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 as described in 411.3 to 411.6.

### **411.7.4 Sources of FELV**

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

If an extra-low voltage system is supplied from a higher voltage system by equipment which does not provide at least simple separation between that system and the extra-low voltage system, such as an autotransformer, a potentiometer or a semiconductor device, the output circuit is not part of a FELV system and is deemed to be an extension of the input circuit and shall be protected by the protective measure applied to the input circuit.

**NOTE:** This does not preclude connecting a conductor of the FELV circuit to the protective conductor of the primary circuit.

### **411.7.5 Plugs, socket-outlets, LSCs, DCLs and cable couplers**

Every plug, socket-outlet, luminaire supporting coupler (LSC), device for connecting a luminaire (DCL) and cable coupler in a FELV system shall have a protective conductor contact and shall not be dimensionally compatible with those used for any other system in use in the same premises.

## **411.8 Reduced low voltage systems**

### **411.8.1 General**

**411.8.1.1** Where, for functional reasons, the use of extra-low voltage is impracticable and there is no requirement for the use of SELV or PELV, a reduced low voltage system may be used, for which the provisions described in s

411.8.2 to 5 shall be made to provide basic protection and fault protection.

**411.8.1.2** The nominal voltage of the reduced low voltage circuits shall not exceed 110 V AC rms between lines (three-phase 63.5 V to earthed neutral, single-phase 55 V to earthed midpoint).

### **411.8.2 Requirements for basic protection**

Basic protection shall be provided by either:

- (i) basic insulation according to 416.1 corresponding to the maximum nominal voltage of the reduced low voltage system given in 411.8.1.2, or
- (ii) barriers or enclosures in accordance with 416.2.

### 411.8.3 Requirements for fault protection

Fault protection by automatic disconnection of supply shall be provided by means of an overcurrent protective device in each line conductor or by an RCD, and all exposed-conductive-parts of the reduced low voltage system shall be connected to Earth. The earth fault loop impedance at every point of utilization, including socket-outlets, shall be such that the disconnection time does not exceed 5 s.

Where a circuit-breaker is used, the maximum value of earth fault loop impedance ( $Z_s$ ) shall be determined by the formula in 411.4.4. Alternatively, the values specified in Table 41.6 may be used instead of calculation for the nominal voltages ( $U_0$ ) and the types and ratings of overcurrent device listed therein.

Where a fuse is used, the maximum values of earth fault loop impedance ( $Z_s$ ) corresponding to a disconnection time of 5 s are stated in Table 41.6 for nominal voltages ( $U_0$ ) of 55 V and 63.5 V.

For types and rated currents of fuses other than those mentioned in Table 41.6, reference should be made to the appropriate Kenyan Standard to determine the value of  $I_a$  for compliance with 411.4.4, according to the appropriate value of the nominal voltage ( $U_0$ ).

Where fault protection is provided by an RCD, the product of the rated residual operating current ( $I_{\Delta n}$ ) in amperes and the earth fault loop impedance in ohms shall not exceed 50 V.

**TABLE 41.6 –  
Maximum earth fault loop impedance ( $Z_s$ ) for 5 s disconnection time and  $U_0$   
of 55 V (single-phase) and 63.5 V (three-phase)  
(see s 411.8.1.2 and 411.8.3)**

	Circuit-breakers to KS IEC 60898 and the overcurrent characteristics of RCBOs to IEC 61009-1 Type				General purpose (gG) fuses to KS IEC 60269-1 – fuse systems E and G	
	B		C and D			
$U_0$ (Volts)	55	63.5	55	63.5	55	63.5
Rating amperes	$Z_s$ ohms					
3	3.48	4.02	1.74	2.01		
6	1.74	2.01	0.87	1.01	2.90	3.35
10	1.05	1.21	0.52	0.60	1.63	1.89
16	0.65	0.75	0.33	0.38	0.95	1.10
20	0.52	0.60	0.26	0.30	0.67	0.77
25	0.42	0.48	0.21	0.24	0.52	0.60
					-	-
32	0.33	0.38	0.16	0.19	0.42	0.48
40	0.26	0.30	0.13	0.15	0.31	0.35
50	0.21	0.24	0.10	0.12	0.24	0.27
63	0.17	0.19	0.08	0.10	0.19	0.22
80	0.13	0.15	0.07	0.08	0.13	0.15
100	0.10	0.12	0.05	0.06	0.12	0.14
125	0.08	0.10	0.04	0.05	0.08	0.09
$I_n$	$10.4/I_n$	$12.1/I_n$	$5.2/I_n$	$6.1/I_n$		

**NOTE 1:** The circuit loop impedances have been determined using a value for factor  $C_{min}$  of 0.95.

**NOTE 2:** The circuit loop impedances given in the table should not be exceeded when:

- the line conductors are at the appropriate maximum permitted operating temperature, as given in Table 52.1, and
- the circuit protective conductors are at the appropriate assumed initial temperature, as given in Tables 54.2 to 54.6.

**NOTE 3:** Where the line conductor insulation is of a type for which Table 52.1 gives a maximum permitted operating temperature exceeding 70 °C, such as thermosetting, but the conductor has been sized in accordance with 512.1.5:

- (i) the maximum permitted operating temperature for the purpose of Note 2(i) is 70 °C, and
- (ii) the assumed initial temperature for the purpose of Note 2(ii) is that given in Tables 54.2 to 54.4 corresponding to an insulation material of 70 °C thermoplastic.

**NOTE 4:** Data for fuses of rating exceeding 200 A should be obtained from the manufacturer.

#### **411.8.4 Sources of Reduced Low Voltage**

**411.8.4.1** The source of supply to a reduced low voltage circuit shall be one of the following:

- (i) A double-wound isolating transformer complying with IEC 61558-1 and IEC 61558-2-23
- (ii) A motor-generator set having windings providing isolation equivalent to that provided by the windings of an isolating transformer
- (iii) A source independent of other supplies, e.g. an engine-driven generator.

**411.8.4.2** The neutral (star) point of the secondary windings of three-phase transformers and generators, or the midpoint of the secondary windings of single-phase transformers and generators, shall be connected to Earth.

#### **411.8.5 Requirements for circuits**

Every plug, socket-outlet, luminaire supporting coupler (LSC), device for connecting a luminaire (DCL) and cable coupler of a reduced low voltage system shall have a protective conductor contact and shall not be dimensionally compatible with those used for any other system in use in the same premises.

### **412 PROTECTIVE MEASURE: DOUBLE OR REINFORCED INSULATION**

#### **412.1 General**

**412.1.1** Double or reinforced insulation is a protective measure in which:

- (iii) basic protection is provided by basic insulation and fault protection is provided by supplementary insulation, or
- (iv) 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 a dangerous voltage on the accessible parts of electrical equipment through a fault in the basic insulation.

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

**412.1.2** 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 effective measures, for example by adequate supervision, are in place so that no change can be made that would impair the effectiveness of the protective measure. Therefore this protective measure shall not be applied to any circuit that includes, for example, a socket-outlet with an earthing contact, luminaire supporting coupler (LSC), device for connecting a luminaire (DCL) or cable coupler, 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 double or reinforced insulation is used for the complete installation or part thereof, electrical equipment shall comply with one of the following:

- (i) 412.2.1.1, or
- (ii) Section 412.2.1.2 and 412.2.2, or
- (iii) Section 412.2.1.3 and 412.2.2.

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

- (i) electrical equipment having double or reinforced insulation (Class II equipment)
- (ii) electrical equipment declared in the relevant product standard as equivalent to Class II, such as assemblies of electrical equipment having total insulation (see KS IEC 61439 series).

**NOTE:** This equipment is identified by the symbol  refer to IEC 60417: 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 s 412.2.2.1 to 412.2.2.3.

**NOTE:** The symbol  should be fixed in a visible position both on the exterior and interior of the enclosure.

**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 s 412.2.2.2 and 412.2.2.3. Such insulation is recognized only where constructional features prevent the application of double insulation.

**NOTE:** The symbol  should be fixed in a visible position both on the exterior and interior of the enclosure.

## **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:

- (i) the insulating enclosure shall not be traversed by conductive parts likely to transmit a potential; and
- (ii) 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 equipment), 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 a lid or door 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 the 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 protective conductor (PE) terminals.

No exposed-conductive-parts or intermediate part shall be connected to a protective conductor unless specific provision for this is made in the specification 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 412.1.2 applies, a circuit supplying one or more 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 Chapter 52 are considered to meet the requirements of 412.2 if:

- (i) the rated voltage of the cable(s) is not less than the nominal voltage of the system and at least 300/500 V, and
- (ii) adequate mechanical protection of the basic insulation is provided by one or more of the following:
  - (a) The non-metallic sheath of the cable
  - (b) Non-metallic trunking or ducting complying with the IEC 50085 series of standards, or non-metallic conduit complying with the IEC 61386 series of standards.

**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:** A wiring system should not be identified by the symbol  $\text{---}$  or by the symbol  $\text{---}$ .

## 413 PROTECTIVE MEASURE: ELECTRICAL SEPARATION

### 413.1 General

**413.1.1** Electrical separation is a protective measure in which:

- (i) basic protection is provided by basic insulation of live parts or by barriers or enclosures in accordance with Section 416, and
- (ii) 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 that the basic insulation complies with the relevant 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 418.3 shall be met.

### 413.2 Requirements for basic protection

All electrical equipment shall be subject to one of the basic protective provisions in Section 416 or to the protective measures in Section 412.

### 413.3 Requirements for fault protection

**413.3.1** Protection by electrical separation shall comply with section 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.

For electrical separation, arrangements shall be such that basic insulation is achieved between circuits in compliance with 416.1.

**413.3.4** Flexible cables 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, insulating ducting or insulating trunking shall be used, provided that:

- (i) the rated voltage is not less than the highest nominal voltage, and
- (ii) 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 also on the protective provisions to which the latter exposed-conductive-parts are subject.

## **414 PROTECTIVE MEASURE: EXTRA-LOW VOLTAGE PROVIDED BY SELV OR 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:

- (i) SELV, or
- (ii) PELV.

Protection by extra-low voltage provided by SELV or PELV requires:

- (iii) limitation of voltage in the SELV or PELV system to the upper limit of voltage Band I, 50 V AC or 120 V DC (see IEC 61140), and
- (iv) 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
- (v) for SELV systems only, basic insulation between the SELV system and Earth.

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

**NOTE:** In certain cases KS 662-7 limits the value of the extra-low voltage to a value lower than 50 V AC or 120 V DC.

### **414.2 Requirements for basic protection and fault protection**

Both basic protection and fault protection are deemed to be provided where:

- (i) the nominal voltage cannot exceed the upper limit of voltage Band I, and
- (ii) the supply is from one of the sources listed in 414.3, and
- (iii) 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 AC voltage circuit to supply the rectifier stack. This internal AC voltage exceeds the DC voltage. The internal AC circuit is not to be considered as a higher voltage circuit within the meaning of this . Between internal circuits and external higher voltage circuits, protective separation is required.

**NOTE 3:** In DC 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 . The charging voltage should not exceed a maximum value of 75 V AC or 150 V DC as appropriate according to the environmental situation as given in Table 1 of PD 6536 (IEC 61201).

### **414.3 Sources for SELV and PELV**

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

- (i) A safety isolating transformer in accordance with IEC 61558-2-6 or IEC 61558-2-8
- (ii) A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified in (i) (e.g. motor-generator with windings providing equivalent isolation)
- (iii) An electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator)
- (iv) Certain electronic devices complying with appropriate standards, where provisions have been taken such 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 where, 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 the value specified in 414.1.1 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 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 ohms.

A mobile source supplied at low voltage, e.g. a safety isolating transformer or a motor-generator, shall be selected and erected in accordance with the requirements for protection by the use of double or reinforced insulation (see Section 412).

#### 414.4 Requirements for SELV and PELV circuits

414.4.1 SELV and PELV circuits shall have:

- (i) basic insulation between live parts and other SELV or PELV circuits, and
- (ii) 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 and 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 or PELV circuits from the live parts of other circuits, which have at least basic insulation, shall be achieved by one of the following arrangements:

- (i) SELV and PELV circuit conductors enclosed in a non-metallic sheath or insulating enclosure in addition to basic insulation
- (ii) SELV and PELV circuit conductors separated from conductors of circuits at voltages higher than Band I by an earthed metallic sheath or earthed metallic screen
- (iii) 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
- (iv) The wiring systems of other circuits are in compliance with 412.2.4.1
- (v) Physical separation.

414.4.3 Every socket-outlet and luminaire supporting coupler in a SELV or PELV system shall require the use of a plug which is not dimensionally compatible with those used for any other system in use in the same premises.

Plugs and socket-outlets in a SELV system 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 AC or 60 V DC or if the equipment is immersed, basic protection shall be provided for SELV and PELV circuits by:

- (i) insulation in accordance with 416.1
- (ii) barriers or enclosures in accordance with 416.2.

Basic protection is generally unnecessary in normal dry conditions for:

- (i) SELV circuits where the nominal voltage does not exceed 25 V AC or 60 V DC
- (ii) PELV circuits where the nominal voltage does not exceed 25 V AC or 60 V DC 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 AC or 30 V DC.

#### 415 ADDITIONAL PROTECTION

**NOTE:** Additional protection in accordance with Section 415 may be specified with the protective measure. In particular, additional protection may be required with the protective measure under certain conditions of external influence and in certain special locations (see the corresponding section of Part 7).

##### 415.1 Additional protection: RCDs

415.1.1 The use of RCDs with a rated residual operating current not exceeding 30 mA is recognized in AC 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.

**415.1.2** The use of RCDs is not recognized as a sole means of protection and does not obviate the need to apply one of the protective measures specified in Sections 411 to 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 equipment, or a location.

**NOTE 4:** Additional requirements may be necessary for special locations (see the corresponding section of Part 7), 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** The resistance  $R$  between simultaneously accessible exposed-conductive-parts and extraneous- conductive-parts shall fulfil the following condition:

$$R \leq 50 \text{ V}/I_a \quad \text{in AC systems}$$

$$R \leq 120 \text{ V}/I_a \quad \text{in DC systems}$$

where  $I_a$  is the operating current in amperes (A) of the protective device or:

- (i) for RCDs,  $I_{\Delta n}$
- (ii) for overcurrent devices, the 5 s operating current.

#### **416 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.

##### **416.1 Basic insulation of 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 such electrical equipment.

**NOTE:** The insulation is intended to prevent contact with live parts. Paint, varnish, lacquer or similar products are generally not considered to provide adequate insulation for basic protection in normal service.

##### **416.2 Barriers or enclosures**

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

**416.2.1** 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:

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

**416.2.2** A horizontal top surface of a barrier or enclosure which is readily accessible shall provide a degree of protection of at least IPXXD or IP4X.

**416.2.3** A barrier or enclosure shall be firmly secured in place and have sufficient stability and durability to maintain the required degree of protection and appropriate separation from live parts in the known conditions of normal service, taking account of relevant external influences.

**416.2.4** Where it is necessary to remove a barrier or open an enclosure or remove parts of enclosures, this shall be possible only:

- (i) by the use of a key or tool, or
- (ii) 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 barrier or enclosure, or
- (iii) 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.

**NOTE:** This does not apply to:

- a ceiling rose
- a cord operated switch complying with IEC 60669-1
- a bayonet lampholder complying with IEC 61184
- an Edison screw lampholder complying with IEC 60238.

**416.2.5** If, behind a barrier or in an enclosure, an item of equipment such as a capacitor is installed which may retain a dangerous electrical charge after it has been switched off, a warning label shall be provided. Small capacitors such as those used for arc extinction and 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 charge falls below 120 V DC in less than 5 s after disconnection from the power supply.

## **417 OBSTACLES AND PLACING OUT OF REACH**

### **417.1 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 persons.

The conditions of supervision under which the basic protective provisions of Section 417 may be applied as part of the protective measure are given in 410.3.5.

### **417.2 Obstacles**

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

**417.2.1** Obstacles shall prevent:

- (i) unintentional bodily approach to live parts, and
- (ii) unintentional contact with live parts during the operation of live equipment in normal service.

**417.2.2** An obstacle may be removed without the use of a key or tool but shall be secured so as to prevent unintentional removal.

### **417.3 Placing out of reach**

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

A bare or insulated overhead line for distribution between buildings and structures shall be installed to the standard .

**417.3.1** Simultaneously accessible parts at different potentials shall not be within arm's reach.

A bare live part other than an overhead line shall not be within arm's reach or within 2.5 m of the following:

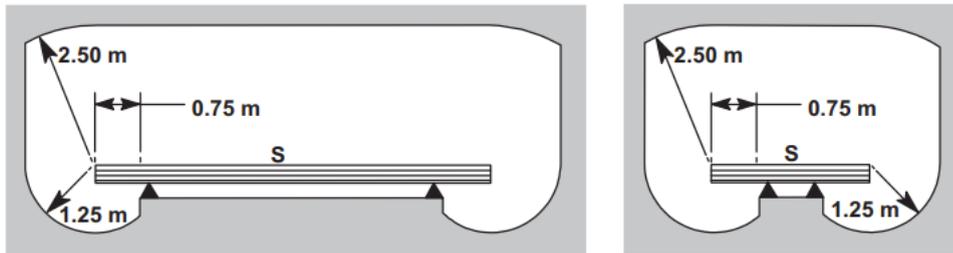
- (i) An exposed-conductive-part
- (ii) An extraneous-conductive-part
- (iii) A bare live part of any other circuit.

**NOTE:** Two parts are deemed to be simultaneously accessible if they are not more than 2.50 m apart (see Figure 417).

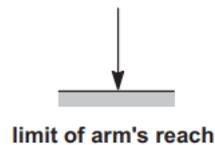
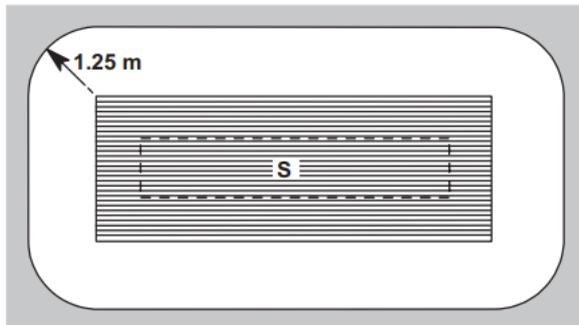
**417.3.2** If a normally occupied position is restricted in the horizontal direction by an obstacle (e.g. handrail, mesh screen) affording a degree of protection less than IPXXB or IP2X, arm's reach shall extend from that obstacle. In the overhead direction, arm's reach is 2.50 m from the surface, S, 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).

Fig 417 – Arm's reach



S = surface expected to be occupied by persons



The values refer to bare hands without any assistance, e.g. from tools or a ladder.

**417.3.3** In places where bulky or long conductive objects are normally handled, the distances required by 417.3.1 and 417.3.2 shall be increased, taking account of the relevant dimensions of those objects.

**418 PROTECTIVE MEASURES FOR APPLICATION ONLY WHERE THE INSTALLATION IS CONTROLLED OR UNDER THE SUPERVISION OF SKILLED OR INSTRUCTED PERSONS**

**NOTE:** The conditions of supervision under which the fault protective provisions of Section 418 may be applied as part of the protective measure are given in 410.3.6.

**418.1 Non-conducting location**

This method of protection is not recognized for general application.

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

**418.1.1** All electrical equipment shall comply with one of the provisions for basic protection described in Section 416.

**418.1.2** Exposed-conductive-parts shall be arranged so that under ordinary circumstances persons will not come into simultaneous contact with:

- (i) two exposed-conductive-parts, or
- (ii) an exposed-conductive-part and any extraneous-conductive-part

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

**418.1.3** In a non-conducting location there shall be no protective conductor.

**418.1.4** 418.1.2 is fulfilled if the location has an insulating floor and walls and one or more of the following arrangements applies:

- (i) 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.

- (ii) 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 (i) above. They shall not be connected to Earth or to exposed-conductive-parts; as far as possible they shall be of insulating material.

- (iii) 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.

**418.1.5** The resistance of insulating floors and walls at every point of measurement under the conditions specified in Part 6 shall be not less than:

- (i) 50 k $\Omega$ , where the nominal voltage of the installation does not exceed 500 V, or
- (ii) 100 k $\Omega$ , 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 electric shock.

**418.1.6** The arrangements made shall be permanent and it shall not be possible to make them ineffective. The arrangements shall also provide protection where the use of mobile 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 Class I equipment, or extraneous-conductive-parts such as metallic water pipes), which may invalidate compliance with 418.1.6.

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

**418.1.7** Precautions shall be taken so that extraneous-conductive-parts cannot cause a potential to appear external to the location concerned.

## **418.2 Protection by earth-free local equipotential bonding**

This method of protection shall be used only in special circumstances.

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

**418.2.1** All electrical equipment shall comply with one of the provisions for basic protection described in Section 416.

**418.2.2** Protective bonding conductors shall interconnect every simultaneously accessible exposed-conductive-part and extraneous-conductive-part.

**418.2.3** The local protective bonding conductors shall neither 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 Section 411).

**418.2.4** Precautions shall be taken so 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 protective bonding conductors.

**418.2.5** Where this measure is applied, a warning notice complying with 514.13.2 shall be fixed in a prominent position adjacent to every point of access to the location concerned.

## **418.3 Electrical separation for the supply to more than one item of current-using equipment**

Where the measure is used to supply two or more items of equipment from a single source, a warning notice complying with 514.13.2 shall be fixed in a prominent position adjacent to every point of access to the location concerned.

**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.

**418.3.1** All electrical equipment shall comply with one of the provisions for basic protection described in Section 416.

**418.3.2** Protection by electrical separation for the supply to more than one item of equipment shall be achieved by compliance with all the requirements of Section 413 except 413.1.2, and with the requirements in s 418.3.3 to 8.

**418.3.3** Precautions shall be taken to protect the separated circuit from damage and insulation failure.

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

**NOTE:** See Note to 413.3.6.

**418.3.5** Every socket-outlet shall be provided with a protective conductor contact which shall be connected to the equipotential bonding system provided in accordance with 418.3.4.

**418.3.6** Except where supplying equipment with double or reinforced insulation, all flexible cables shall embody a protective conductor for use as a protective bonding conductor in accordance with 418.3.4.

**418.3.7** 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 disconnection time conforming with Table 41.1.

**418.3.8** The product of the nominal voltage of the circuit in volts and length of the wiring system in metres shall not exceed 100 000 Vm, and the length of the wiring system shall not exceed 500 m.

#### **419 PROVISIONS WHERE AUTOMATIC DISCONNECTION ACCORDING TO 411.3.2 IS NOT FEASIBLE**

**419.1** Where automatic disconnection is not feasible in circumstances where:

- (i) electronic equipment with limited short-circuit current is installed, or
- (ii) the required disconnection times cannot be achieved by a

protective device the provisions of s 419.2 and 419.3 are applicable.

**419.2** For installations with power electronic convertors with nominal voltage  $U_0$  greater than 50 V AC or 120 V DC and where automatic disconnection is not feasible, the output voltage of the source shall be reduced to 50 V AC or 120 V DC or less in the event of a fault between a live conductor and the protective conductor or Earth in a time as given in 411.3.2.2, 411.3.2.3 or 411.3.2.4, as appropriate (see IEC 62477-1).

The power electronic convertor shall be one for which the manufacturer gives adequate methods for the initial verification and periodic inspection and testing of the installation.

**419.3** Except where 419.2 applies, if automatic disconnection 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 and the voltage between simultaneously accessible exposed-conductive-parts and/or extraneous-conductive-parts shall not exceed 50 V AC or 120 V DC.

CHAPTER 42  
**PROTECTION AGAINST THERMAL EFFECTS**

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**CHAPTER 42**

**420.1 Scope**

This chapter applies to electrical installations and equipment with regard to measures for the protection of persons, livestock and property against:

- (i) the harmful effects of heat or thermal radiation developed by electrical equipment
- (ii) the ignition, combustion or degradation of materials
- (iii) flames and smoke where a fire hazard could be propagated from an electrical installation to other nearby fire compartments, and
- (iv) safety services being cut off by the failure of electrical equipment.

**NOTE 1:** For protection against thermal effects and fire, statutory requirements may be applicable.

**NOTE 2:** Protection against overcurrent is dealt with in Chapter 43 of these s.

**421 PROTECTION AGAINST FIRE CAUSED BY ELECTRICAL EQUIPMENT**

**421.1 General requirements**

**421.1.1** Persons, livestock and property shall be protected against harmful effects of heat or fire which may be generated or propagated in electrical installations.

Manufacturers' instructions shall be taken into account in addition to the requirements of KS 662.

**NOTE 1:** Harmful effects of heat or fire may be caused by:

- heat accumulation, heat radiation, hot components or equipment
- failure of electrical equipment such as protective devices, switchgear, thermostats, temperature limiters, seals of cable penetrations and wiring systems
- overcurrent
- insulation faults or arcs, sparks and high temperature particles
- harmonic currents
- external influences such as lightning surge
- inappropriate selection or erection of equipment.

**NOTE 2:** Lightning strikes and overvoltages are covered in IEC 62305.

**421.1.2** Fixed electrical equipment shall be selected and erected such that its temperature in normal operation

will not cause a fire. This shall be achieved by the construction of the equipment or by additional protective measures taken during erection.

The heat generated by electrical equipment shall not cause danger or harmful effects to adjacent fixed material or to material which may foreseeably be in proximity to such equipment.

Where fixed equipment may attain surface temperatures which could cause a fire hazard to adjacent materials, one or more of the following installation methods shall be adopted. The equipment shall:

- (i) be mounted on a support which has low thermal conductance or within an enclosure which will withstand, with minimal risk of fire or harmful thermal effect, such temperatures as may be generated, or
- (ii) be screened by materials of low thermal conductance which can withstand, with minimal risk of fire or harmful thermal effect, the heat emitted by the electrical equipment, or
- (iii) be mounted so as to allow safe dissipation of heat and at a sufficient distance from adjacent material on which such temperatures could have deleterious effects. Any means of support shall be of low thermal conductance.

**421.1.3** Where arcs, sparks or particles at high temperature may be emitted by fixed equipment in normal service, the equipment shall meet one or more of the following requirements. It shall be:

- (i) totally enclosed in arc-resistant material
- (ii) screened by arc-resistant material from materials upon which the emissions could have harmful effects
- (iii) mounted so as to allow safe extinction of the emissions at a sufficient distance from materials upon which the emissions could have harmful effects
- (iv) in compliance with its standard.

Arc-resistant material used for this protective measure shall be non-ignitable, of low thermal conductivity and of adequate thickness to provide mechanical stability.

**421.1.4** Fixed equipment causing a concentration and focusing of heat shall be at a sufficient distance from any fixed object or building element so that the object or element is not subjected to a dangerous temperature in normal conditions.

**421.1.5** Where electrical equipment in a single location contains flammable liquid in significant quantity, adequate precautions shall be taken to prevent the spread of liquid, flame and the products of combustion.

**NOTE 1:** Examples of such precautions are:

- (a) a retention pit of sufficient size to collect any leakage of liquid and provide extinction in the event of fire
- (b) installation of the equipment in a chamber of adequate fire-resistance and the provision of sills or other means of preventing burning liquid spreading to other parts of the building, such a chamber being ventilated solely to the external atmosphere.

**NOTE 2:** The generally accepted lower limit for a significant quantity is 25 litres.

**NOTE 3:** For quantities less than 25 litres, it is sufficient to take precautions to prevent the escape of liquid.

**NOTE 4:** Products of combustion of liquid are considered to be smoke and gas.

**421.1.201** Within domestic (household) premises, consumer units and similar switchgear assemblies shall comply with KS IEC 61439-3 and shall:

- (i) have their enclosure manufactured from non-combustible material, or
- (ii) be enclosed in a cabinet or enclosure constructed of non-combustible material and complying with 132.12.

**NOTE:** Ferrous metal, e.g. steel, is deemed to be an example of a non-combustible material.

**421.1.6** Materials used for the construction of enclosures of electrical equipment shall comply with the resistance to heat and fire requirements in an appropriate product standard.

Where no product standard exists, the materials of an enclosure shall withstand the highest temperature likely to be produced by the electrical equipment in normal use.

**421.1.7** Arc fault detection devices conforming to IEC 62606 are recommended as a means of providing additional protection against fire caused by arc faults in AC final circuits.

If used, an AFDD shall be placed at the origin of the circuit to be protected.

**NOTE:** Examples of where such devices can be used include:

- premises with sleeping accommodation
- locations with a risk of fire due to the nature of processed or stored materials, i.e. BE2 locations (e.g. barns woodworking shops, stores of combustible materials)
- locations with combustible constructional materials, i.e. CA2 locations (e.g. wooden buildings)
- fire propagating structures, i.e. CB2 locations
- locations with endangering of irreplaceable goods.

## **422 PRECAUTIONS WHERE PARTICULAR RISKS OF FIRE EXIST**

### **422.1 General**

The requirements of this shall be applied in addition to those of Section 421 for installations in locations where any of the conditions of external influence described in s 422.2 to 6 exist.

**422.1.1** Except for wiring systems meeting the requirements of 422.3.5, electrical equipment shall be restricted to that necessary to the use of the locations given in 422.1.

**422.1.2** Electrical equipment shall be so selected and erected that its normal temperature rise and foreseeable temperature rise during a fault cannot cause a fire. This shall be achieved by the construction of the equipment or by additional protective measures taken during erection.

Special measures are not necessary where the temperature of surfaces is unlikely to cause combustion of nearby substances.

**422.1.3** A temperature cut-out device shall have manual reset only.

### **422.2 Conditions for evacuation in an emergency**

The following refer to conditions:

BD2: Low density occupation, difficult conditions of evacuation

BD3: High density occupation, easy conditions of evacuation

BD4: High density occupation, difficult conditions of evacuation.

(Refer to Appendix 2.)

**NOTE:** Authorities such as those responsible for building construction, public gatherings, fire prevention, hospitals, etc. may specify which BD condition is applicable.

**422.2.1** Cables shall not encroach on escape routes unless they meet the recommended requirements of the relevant part of KS IEC 60332-3 series and achieve at least 60 % light transmittance when tested in accordance with KS IEC 61034-2. Cables in escape routes shall be as short as practicable. Cables encroaching on escape routes shall not be installed within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation.

Where used, cable management systems shall be one or more of the following types:

- (i) conduit systems classified as non-flame propagating according to IEC 61386
- (ii) cable trunking systems and cable ducting systems classified as non-flame propagating according to IEC 61084.
- (iii) cable tray and cable ladder systems classified as non-flame propagating according to IEC 61537, or
- (iv) powertrack systems meeting the requirements of IEC 61534.

Cables that are supplying safety circuits shall have a resistance to fire rating of either the time authorized by Kenyan standard for building elements for the circuits or one hour in the absence of such a standard.

**422.2.2** In conditions BD2, BD3 or BD4, switchgear or controlgear shall be accessible only to authorized persons. If switchgear or controlgear is placed in an escape route, it shall be enclosed in a cabinet or an enclosure constructed of non-combustible or not readily combustible material.

These requirements do not apply to items of switchgear or controlgear installed to facilitate evacuation, such as fire alarm call points.

**422.2.3** In escape routes where conditions BD3 or BD4 exist, the use of electrical equipment containing flammable liquids is not permitted.

This requirement does not apply to individual capacitors incorporated in equipment, such as a capacitor installed in a discharge luminaire or a motor starter.

### **422.3 Locations with risks of fire due to the nature of processed or stored materials**

The requirements of this shall be applied in addition to those of Section 421 in locations where BE2 conditions exist.

This does not apply to selection and erection of installations in locations with explosion risks, see KS IEC 60079-14 and IEC 61241-14.

**NOTE 1:** BE2 conditions exist where there is a risk of fire due to the manufacture, processing or storage of flammable materials including the presence of dust (see Appendix 2).

**NOTE 2:** Examples of locations presenting BE2 conditions include barns (due to the accumulation of dust and fibres), woodworking facilities, paper mills and textile factories (due to the storage and processing of combustible materials).

**NOTE 3:** Quantities of flammable materials or the surface or volume of the location may be regulated by national authorities.

**422.3.1** Except for equipment for which an appropriate product standard specifies requirements, a luminaire shall be kept at an adequate distance from combustible materials. Unless otherwise recommended by the manufacturer, a small spotlight or projector shall be installed at the following minimum distance from combustible materials:

(i)	Rating up to 100 W	0.5 m
(ii)	Over 100 and up to 300 W	0.8 m
(iii)	Over 300 and up to 500 W	1.0 m.

Lamps and other components of luminaires shall be protected against foreseeable mechanical stresses. Such protective means shall not be fixed to lampholders unless they form an integral part of the luminaire or are fitted in accordance with the manufacturer's instructions.

A luminaire with a lamp that could eject flammable materials in case of failure shall be constructed with a safety protective shield for the lamp in accordance with the manufacturer's instructions.

**422.3.2** Measures shall be taken to prevent an enclosure of electrical equipment such as a heater or resistor from exceeding the following temperatures:

- (i) 90 °C under normal conditions, and
- (ii) 115 °C under fault conditions.

Where materials such as dust or fibres sufficient to cause a fire hazard could accumulate on an enclosure of electrical equipment, adequate measures shall be taken to prevent the enclosure from exceeding the temperatures stated above.

**NOTE:** Luminaires marked in compliance with KS IEC 60598-2-24 have limited surface temperature.

**422.3.3** Switchgear or controlgear shall be installed outside the location unless:

- (i) it is suitable for the location, or
- (ii) it is installed in an enclosure providing a degree of protection of at least IP4X or, in the presence of dust, IP5X or, in the presence of electrically conductive dust, IP6X, except where 422.3.11 applies.

**422.3.4** A cable shall as a minimum meet the requirements of IEC 60332-1-2.

A cable not completely embedded in non-combustible material such as plaster or concrete or otherwise protected from fire shall as a minimum meet the requirements of IEC 60332-1-2.

A conduit system shall satisfy the test under fire conditions specified in IEC 61386-1.

A cable trunking system or cable ducting system shall satisfy the test under fire conditions specified in the appropriate part of the IEC 61084 series.

A cable tray system or cable ladder shall satisfy the test under fire conditions specified in IEC 61537.

A powertrack system shall satisfy the test for resistance to flame propagation specified in the appropriate part of the IEC 61534 series.

Wiring systems shall be selected and installed to minimize the propagation of flame.

Where the risk of flame propagation is high the cable shall meet the requirements of the appropriate part of IEC 60332-3 series.

**NOTE 1:** The risk of flame propagation can be high where cables are bunched or installed in long vertical runs.

**422.3.5** A wiring system which passes through the location but is not intended to supply electrical equipment in the location shall:

- (i) meet the requirements of 422.3.4, and
- (ii) have no connection or joint within the location, unless the connection or joint is installed within an enclosure that does not adversely affect the flame propagation characteristics of the wiring system, and
- (iii) be protected against overcurrent in accordance with the requirements of 422.3.10, and
- (iv) not employ bare live conductors.

**422.3.6** *Not used*

**422.3.7** A motor which is automatically or remotely controlled or which is not continuously supervised shall be protected against excessive temperature by a protective device with manual reset. A motor shall be protected against overtemperature in all operational modes.

**422.3.8** Every luminaire shall:

- (i) be appropriate for the location, and
- (ii) be provided with an enclosure providing a degree of protection of at least IP4X or, in the presence of dust, IP5X or, in the presence of electrically conductive dust, IP6X, and
- (iii) have a limited surface temperature in accordance with KS IEC 60598-2-24, and
- (iv) be of a type that prevents lamp components from falling from the luminaire.

In locations where there may be fire hazards due to dust or fibres, luminaires shall be installed so that dust or fibres cannot accumulate in dangerous amounts.

**422.3.9** Wiring systems, other than mineral insulated cables, busbar trunking systems or powertrack systems, shall be protected against insulation faults:

- (i) in a TN or TT system, by an RCD having a rated residual operating current ( $I_{\Delta n}$ ) not exceeding 300 mA according with 531.3.2 and to relevant product standards.

Where a resistive fault may cause a fire, e.g. for overhead heating with heating film elements, the rated residual operating current shall not exceed 30 mA.

- (ii) in an IT system, by an insulation monitoring device with audible and visual signals provided in accordance with 538.1. Disconnection times in the event of a second fault are given in Chapter 41. Alternatively, RCDs with a rated residual operating current as specified in (i) may be used. In the event of a second fault, see Chapter 41 for disconnection times.

**422.3.10** Circuits supplying or traversing locations where BE2 conditions exist shall be protected against overload and against fault current by protective devices located outside and on the supply side of these locations. Circuits originating inside these locations shall be protected against overcurrent by protective devices located at their origin.

**422.3.11** Regardless of the nominal voltage of a circuit supplied at extra-low voltage, live parts shall be either:

- (i) contained in enclosures affording a degree of protection of at least IPXXB or IP2X, or
- (ii) provided with insulation capable of withstanding a test voltage of 500 V DC for

1 minute. These requirements are in addition to those of Section 414.

**422.3.12** A PEN conductor shall not be used. This requirement does not apply to a circuit traversing the location.

**422.3.13** Except as permitted by 461.2, every circuit shall be provided with a means of isolation from all live supply conductors by a linked switch or a linked circuit-breaker.

**NOTE:** Provision may be made for isolation of a group of circuits by a common means, if the service conditions allow this.

**422.3.201** Flexible cables shall be of the following construction:

- (i) Heavy duty type having a voltage rating of not less than 450/750 V, or
- (ii) suitably protected against mechanical damage.

**NOTE 1:** Descriptions of light, ordinary and heavy duty types are given in KS IEC 60287.

**NOTE 2:** Suitable flexible heavy duty cables can be found in IEC 62440 (conventional elastomeric types) and IEC 62821 (low smoke, halogen-free types).

**422.3.202** A heating appliance shall be fixed.

**422.3.203** A heat storage appliance shall be of a type which prevents the ignition of combustible dusts or fibres by the heat storing core.

#### **422.4 Combustible constructional materials**

The requirements of this shall be applied in addition to those of Section 421 in locations where CA2 conditions exist.

**NOTE:** CA2 conditions exist where a building is mainly constructed of combustible materials, such as wood (see Appendix 2).

**422.4.1** Precautions shall be taken so that electrical equipment does not ignite walls, floors or ceilings. In prefabricated hollow walls containing a pre-installed wiring system including accessories, all boxes and enclosures shall have a degree of protection of at least IP3X where the wall is liable to be drilled during erection.

**422.4.2** Except for equipment for which an appropriate product standard specifies requirements, a luminaire shall be kept at an adequate distance from combustible materials. Unless otherwise recommended by the manufacturer, a small spotlight or projector shall be installed at the following minimum distance from combustible materials:

- |       |                          |        |
|-------|--------------------------|--------|
| (i)   | Rating up to 100 W       | 0.5 m  |
| (ii)  | Over 100 and up to 300 W | 0.8 m  |
| (iii) | Over 300 and up to 500 W | 1.0 m. |

Lamps and other components of luminaires shall be protected against foreseeable mechanical stresses. Such protective means shall not be fixed to lampholders unless they form an integral part of the luminaire or are fitted in accordance with the manufacturer's instructions.

A luminaire with a lamp that could eject flammable materials in case of failure shall be constructed with a safety protective shield for the lamp in accordance with the manufacturer's instructions.

**NOTE:** Refer to Table 55.3 regarding the marking of luminaires and their installation or mounting on normally flammable surfaces.

**422.4.201** Electrical equipment, e.g. installation boxes and distribution boards, installed on or in a combustible wall shall comply with the relevant standard for enclosure temperature rise.

**422.4.202** Electrical equipment that does not comply with 422.4.201 shall be enclosed with a suitable thickness of non-flammable material. The effect of the material on the heat dissipation from electrical equipment shall be taken into account.

**422.4.203** Cables shall comply with the requirements of KS IEC 60332-1-2.

**422.4.204** Conduit and trunking systems shall be in accordance with KS IEC 61386-1 and IEC 61084-1 respectively and shall meet the fire-resistance tests within these standards.

#### **422.5 Fire propagating structures**

The requirements of this shall be applied in addition to those of Section 421 in locations where CB2 conditions exist. Where the risk of flame propagation is high the cable shall meet the requirements of the appropriate part of KS IEC 60332-3 series.

**NOTE 1:** CB2 conditions relate to the propagation of fire and exist where a building has a shape and dimensions which facilitate the spread of fire (e.g. chimney effect), such as high-rise buildings or where a building has a forced ventilation system (see Appendix 2).

**NOTE 2:** Fire detectors may be provided to activate measures for preventing propagation of fire, for example, the closing of fireproof shutters in ducts, troughs or trunking.

**NOTE 3:** Boxes and enclosures according to KS IEC 60670-1 and KS IEC 61439 series for use in hollow walls can be used.

**422.5.1** In structures where the shape and dimensions are such as will facilitate the spread of fire, precautions shall be taken so that the electrical installation does not propagate a fire (e.g. chimney effect).

**422.6 Selection and erection of installations in locations of national, commercial, industrial or public significance**

The requirements of 422.1 shall apply to locations that include buildings or rooms with assets of significant value. Examples include national monuments, museums and other public buildings. Buildings such as railway stations and airports are generally considered to be of public significance. Buildings or facilities such as laboratories, computer centres and certain industrial and storage facilities can be of commercial or industrial significance.

The following measures may be considered:

- (i) Installation of mineral insulated cables according to IEC 60702
- (ii) Installation of cables with improved fire-resisting characteristics in case of a fire hazard, such as those complying with IEC 60331
- (iii) Installation of cables in non-combustible solid walls, ceilings and floors
- (iv) Installation of cables in areas with constructional partitions having a fire-resisting capability for a time of 30 minutes or 90 minutes, the latter in locations housing staircases and needed for an emergency escape.

Where these measures are not practicable improved fire protection may be possible by the use of reactive fire protection systems.

**423 PROTECTION AGAINST BURNS**

**423.1** Excepting equipment for which a Harmonized Standard specifies a limiting temperature, an accessible part of fixed electrical equipment within arm's reach shall not attain a temperature in excess of the appropriate limit stated in Table 42.1. Each such part of the fixed installation likely to attain under normal load conditions, even for a short period, a temperature exceeding the appropriate limit in Table 42.1 shall be guarded so as to prevent accidental contact.

**TABLE 42.1 –  
Temperature limit under normal load  
conditions for an accessible part of equipment  
within arm's reach**

Accessible part	Material of accessible surfaces	Maximum temperature (°C)
A hand-held part	Metallic	55
	Non-metallic	65
A part intended to be touched but not hand-held	Metallic	70
	Non-metallic	80
A part which need not be touched for normal operation	Metallic	80
	Non-metallic	90

**424 PROTECTION AGAINST OVERHEATING**

**424.1 Forced air heating systems, appliances producing hot water or steam, and space heating appliances**

Locations containing forced air heating systems, appliances producing hot water or steam, and space heating appliances, must comply with the appropriate parts of the Building code.

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**PROTECTION AGAINST OVERCURRENT**  
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## CHAPTER 43

### PROTECTION AGAINST OVERCURRENT

#### 430 INTRODUCTION

##### 430.1 Scope

This chapter provides requirements for the protection of live conductors from the effects of overcurrent.

This chapter describes how live conductors are protected by one or more devices for the automatic disconnection of the supply in the event of overload current (Section 433) and fault current (Section 434), except in cases where the overcurrent is limited in accordance with Section 436 or where the conditions described in 433.3 (omission of devices for protection against overload) or 434.3 (omission of devices for protection against fault current) are met. Co-ordination of overload current protection and fault current protection is also covered (Section 435).

**NOTE 1:** Live conductors protected against overload current in accordance with Section 433 are also considered to be protected against faults likely to cause overcurrents of a magnitude similar to overload currents.

**NOTE 2:** The requirements of this chapter do not take account of external influences.

**NOTE 3:** Protection of conductors according to these s does not necessarily protect the equipment connected to the conductors.

**NOTE 4:** Disconnection does not necessarily mean isolation in this chapter.

##### 430.2 *Not used*

##### 430.3 General requirement

A protective device shall be provided to break any overcurrent in the circuit conductors before such a current could cause a danger due to thermal or mechanical effects detrimental to insulation, connections, joints, terminations or the surroundings of the conductors.

The protection against overload current and the protection against fault current shall be co-ordinated in accordance with Section 435.

**NOTE:** An overcurrent may be an overload current or a fault current.

#### 431 PROTECTION ACCORDING TO THE NATURE OF THE CIRCUITS AND THE DISTRIBUTION SYSTEM

##### 431.1 Protection of line conductors

**431.1.1** Except where 431.1.2 applies, detection of overcurrent shall be provided for all line conductors and shall cause the disconnection of the conductor in which the overcurrent is detected, but not necessarily the disconnection of the other line conductors except where the disconnection of one line conductor could cause damage or danger.

If disconnection of a single line conductor may cause danger, for example in the case of a three-phase motor, appropriate precautions shall be taken.

**431.1.2** In a TN or TT system, for a circuit supplied between line conductors and in which the neutral conductor is not distributed, overcurrent detection need not be provided for one of the line conductors, provided that both the following conditions are simultaneously fulfilled:

- (i) There exists, in the same circuit or on the supply side, differential protection intended to detect unbalanced loads and cause disconnection of all the line conductors, and
- (ii) the neutral conductor is not distributed from an artificial neutral point of the circuits situated on the load side of the differential protective device mentioned in (i).

##### 431.2 Protection of the neutral conductor

###### 431.2.1 TN or TT system

The neutral conductor shall be protected against short-circuit current.

Where the cross-sectional area of the neutral conductor is at least equivalent to that of the line conductors, and

the current in the neutral is not expected to exceed the value in the line conductors, it is not necessary to provide overcurrent detection for the neutral conductor or a disconnecting device for that conductor.

Where the cross-sectional area of the neutral conductor is less than that of the line conductors, it is necessary to provide overcurrent detection for the neutral conductor, appropriate to the cross-sectional area of the conductor. The overcurrent detection shall cause the disconnection of the line conductors, but not necessarily of the neutral conductor.

Except for disconnection complying with 461.2 the requirements for a neutral conductor apply to a PEN conductor. Where the current in the neutral conductor is expected to exceed that in the line conductors refer to 431.2.3.

#### **431.2.2 IT system**

The neutral conductor shall not be distributed unless one of the following is met:

- (i) Overcurrent detection is provided for the neutral conductor of every circuit. The overcurrent detection shall cause the disconnection of all the live conductors of the corresponding circuit, including the neutral conductor
- (ii) The particular neutral conductor is effectively protected against short-circuit by a protective device installed on the supply side, for example at the origin of the installation, in accordance with 434.5
- (iii) The particular circuit is protected by an RCD with a rated residual operating current ( $I_{\Delta n}$ ) not exceeding 0.2 times the current-carrying capacity of the corresponding neutral conductor. The RCD shall disconnect all the live conductors of the corresponding circuit, including the neutral conductor. The device shall have sufficient breaking capacity for all poles.

#### **431.2.3 Harmonic currents**

Overcurrent detection shall be provided for the neutral conductor in a polyphase circuit where the harmonic content of the line currents is such that the current in the neutral conductor may exceed the current-carrying capacity of that conductor. The overcurrent detection shall cause disconnection of the line conductors but not necessarily the neutral conductor. Where the neutral is disconnected the requirements of 431.3 are applicable.

#### **431.3 Disconnection and reconnection of the neutral conductor**

Where a switch is placed in a neutral conductor, disconnection and reconnection shall be such that the neutral conductor shall not be disconnected before the line conductors and shall be reconnected at the same time as or before the line conductors.

### **432 NATURE OF PROTECTIVE DEVICES**

A protective device shall be of the appropriate type indicated in s 432.1 to 3.

#### **432.1 Protection against both overload current and fault current**

Except as permitted by 434.5.1, a device providing protection against both overload and fault current shall be capable of breaking, and for a circuit-breaker making, any overcurrent up to and including the maximum prospective fault current at the point where the device is installed.

#### **432.2 Protection against overload current only**

A device providing protection against overload current is generally an inverse-time-lag protective device whose rated short-circuit breaking capacity may be below the value of the maximum prospective fault current at the point where the device is installed. Such a device shall satisfy the relevant requirements of Section 433.

#### **432.3 Protection against fault current only**

A device providing protection against fault current only shall be installed where overload protection is achieved by other means or where Section 433 permits overload protection to be dispensed with. Except as permitted by 434.5.1, a device shall be capable of breaking, and for a circuit-breaker making, the fault current up to and including the prospective fault current. Such a device shall satisfy the relevant requirements of Section 434.

**NOTE:** Such a device may be:

- (i) a circuit-breaker with a short-circuit release, or
- (ii) a fuse.

#### 432.4 Characteristics of protective devices

The time/current characteristics of an overcurrent protective device shall comply with those specified in KS IEC 60269, KS IEC 60898, IEC 60947-2 or KS IEC 61009-1.

The use of another device is not precluded provided that its time/current characteristics provide a level of protection not less than that given by the devices listed above.

### 433 PROTECTION AGAINST OVERLOAD CURRENT

#### 433.1 Co-ordination between conductor and overload protective device

Every circuit shall be designed so that a small overload of long duration is unlikely to occur.

**433.1.1** The operating characteristics of a device protecting a conductor against overload shall satisfy the following conditions:

- (iii) The rated current or current setting of the protective device ( $I_n$ ) is not less than the design current ( $I_b$ ) of the circuit, and
- (iv) the rated current or current setting of the protective device ( $I_n$ ) does not exceed the lowest of the current-carrying capacities ( $I_z$ ) of any of the conductors of the circuit, and
- (v) the current ( $I_2$ ) causing effective operation of the protective device does not exceed 1.45 times the lowest of the current-carrying capacities ( $I_z$ ) of any of the conductors of the circuit.

For adjustable protective devices, the rated current ( $I_n$ ) is the current setting selected.

The current ( $I_2$ ) causing effective operation of the protective device is given in the product standard or may be provided by the manufacturer.

**NOTE 1:** Where overload protection is provided by KS IEC 60269 fuses, refer to 433.1.202.

**NOTE 2:** Protection in accordance with this may not provide protection in all cases, for example, where sustained overcurrents less than  $I_2$  occur.

**433.1.201** Where the protective device is a general-purpose type (gG) fuse to KS IEC 60269-1, a fuse to KS IEC 60269-2, a circuit-breaker to KS IEC 60898, a circuit-breaker to IEC 60947-2 or a residual current circuit-breaker with integral overcurrent protection (RCBO) to KS IEC 61009-1, compliance with conditions (i) and (ii) also results in compliance with condition (iii) of 433.1.1.

**433.1.202** Where the protective device is a semi-enclosed fuse to KS IEC 60269 compliance with condition (iii) of 433.1.1 is afforded if its rated current ( $I_n$ ) does not exceed 0.725 times the current-carrying capacity ( $I_z$ ) of the lowest rated conductor in the circuit protected.

**433.1.203** For direct buried cables or cables in buried ducts where the tabulated current-carrying capacity is based on an ambient temperature of 20 °C compliance with condition (iii) of 433.1.1 is afforded if the rated current or current setting of the protective device ( $I_n$ ) does not exceed 0.9 times the current-carrying capacity ( $I_z$ ) of the lowest rated conductor in the circuit protected.

**433.1.204** Accessories to KS 495 may be supplied through a ring final circuit, with or without unfused spurs, protected by a 30 A or 32 A protective device complying with KS IEC 60898, IEC 60947-2 or KS IEC 61009-1 (RCBO). The circuit shall be wired with copper conductors having line and neutral conductors with a minimum cross-sectional area of 2.5 mm<sup>2</sup> except for two-core mineral insulated cables complying with IEC 60702-1, for which the minimum cross-sectional area is 1.5 mm<sup>2</sup>. Such circuits are deemed to meet the requirements of 433.1.1 if the current-carrying capacity ( $I_z$ ) of the cable is not less than 20 A and if, under the intended conditions of use, the load current in any part of the circuit is unlikely to exceed for long periods the current-carrying capacity ( $I_z$ ) of the cable.

#### 433.2 Position of devices for protection against overload

**433.2.1** Except where 433.2.2 or 433.3 applies, a device for protection against overload shall be installed at the point where a reduction occurs in the value of the current-carrying capacity of the conductors of the installation.

**NOTE:** A reduction in current-carrying capacity may be due to a change in cross-sectional area, method of installation, type of cable or conductor, or in environmental conditions.

**433.2.2** The device protecting a conductor against overload may be installed along the run of that conductor if the part of the run between the point where a change occurs (in cross-sectional area, method of installation, type of cable or conductor, or in environmental conditions) and the position of the protective device has neither branch circuits nor outlets for connection of current-using equipment and fulfils at least one of the following conditions:

- (i) It is protected against fault current in accordance with the requirements stated in Section 434
- (ii) Its length does not exceed 3 m, it is installed in such a manner as to reduce the risk of fault to a minimum, and it is installed in such a manner as to reduce to a minimum the risk of fire or danger to persons (see also 434.2.1).

### **433.3 Omission of devices for protection against overload**

This shall not be applied to installations situated in locations presenting a fire risk or risk of explosion or where the requirements for special installations and locations specify different conditions.

#### **433.3.1 General**

A device for protection against overload need not be provided:

- (i) for a conductor situated on the load side of the point where a reduction occurs in the value of current-carrying capacity, where the conductor is effectively protected against overload by a protective device installed on the supply side of that point
- (ii) for a conductor which, because of the characteristics of the load or the supply, is not likely to carry overload current, provided that the conductor is protected against fault current in accordance with the requirements of Section 434
- (iii) at the origin of an installation where the distributor provides an overload device and agrees that it affords protection to the part of the installation between the origin and the main distribution point of the installation where further overload protection is provided.

#### **433.3.2 Position or omission of devices for protection against overload in IT systems**

**433.3.2.1** The provisions in s 433.2.2 and 433.3 for an alternative position or omission of devices for protection against overload are not applicable to IT systems unless each circuit not protected against overload is protected by one of the following means:

- (i) Use of the protective measures described in 413.2
- (ii) An RCD that will operate immediately on the second fault
- (iii) For permanently supervised systems only, the use of an insulation monitoring device which either:
  - (a) causes the disconnection of the circuit when the first fault occurs, or
  - (b) gives a signal indicating the presence of a fault. The fault shall be corrected in accordance with operational requirements and recognition of the consequences of a second fault.

**433.3.2.2** In an IT system without a neutral conductor it is permitted to omit the overload protective device in one of the line conductors if an RCD is installed in each circuit.

#### **433.3.3 Omission of devices for protection against overload for safety reasons**

The omission of devices for protection against overload is permitted for circuits supplying current-using equipment where unexpected disconnection of the circuit could cause danger or damage.

Examples of such circuits are:

- (i) the exciter circuit of a rotating machine
- (ii) the supply circuit of a lifting magnet
- (iii) the secondary circuit of a current transformer
- (iv) a circuit supplying a fire extinguishing device
- (v) a circuit supplying a safety service, such as a fire alarm or a gas alarm
- (vi) a circuit supplying medical equipment used for life support in specific medical locations where an IT system is incorporated.

**NOTE:** In such situations consideration should be given to the provision of an overload alarm.

#### **433.4 Overload protection of conductors in parallel**

Where a single protective device protects two or more conductors in parallel there shall be no branch circuits or

devices for isolation or switching in the parallel conductors.

This does not preclude the use of ring final circuits with or without spur connections.

#### **433.4.1 Equal current sharing between parallel conductors**

Except for a ring final circuit, where spurs are permitted, where a single device protects conductors in parallel and the conductors are sharing currents equally, the value of  $I_z$  to be used in 433.1.1 is the sum of the current-carrying capacities of the parallel conductors.

It is deemed that current sharing is equal if the requirements of the first indent of 523.7(i) are satisfied.

#### **433.4.2 Unequal current sharing between parallel conductors**

Where the use of a single conductor is impractical and the currents in the parallel conductors are unequal, the design current and requirements for overload protection for each conductor shall be considered individually.

**NOTE:** Currents in parallel conductors are considered to be unequal if the difference between the currents is more than 10 % of the design current for each conductor. Refer to paragraph 2 of Appendix 1.

### **434 PROTECTION AGAINST FAULT CURRENT**

This section only considers the case of a fault between conductors belonging to the same circuit.

#### **434.1 Determination of prospective fault current**

The prospective fault current shall be determined at every relevant point of the installation. This shall be done by calculation, measurement or enquiry.

#### **434.2 Position of devices for protection against fault current**

A device providing protection against fault current shall be installed at the point where a reduction in the cross-sectional area or other change causes a reduction in the current-carrying capacity of the conductors, except where 434.2.1, 434.2.2 or 434.3 applies.

The requirements in s 434.2.1 and 434.2.2 shall not be applied to installations situated in locations presenting a fire risk or risk of explosion or where special requirements for certain locations specify different conditions.

**434.2.1** Except where 434.2.2 or 434.3 applies, a device for protection against fault current may be installed other than as specified in 434.2, under the following conditions:

In the part of the conductor between the point of reduction of cross-sectional area or other change and the position of the protective device there shall be no branch circuits or socket-outlets and that part of the conductor shall:

- (i) not exceed 3 m in length, and
- (ii) be installed in such a manner as to reduce the risk of fault to a minimum, and  
**NOTE:** This condition may be obtained, for example, by reinforcing the protection of the wiring against external influences.
- (iii) be installed in such a manner as to reduce to a minimum the risk of fire or danger to persons.

**434.2.2** The device protecting a conductor may be installed on the supply side of the point where a change occurs (in cross-sectional area, method of installation, type of cable or conductor, or in environmental conditions) provided that it possesses an operating characteristic such that it protects the wiring situated on the load side against fault current, in accordance with 434.5.2.

#### **434.3 Omission of devices for protection against fault current**

A device for protection against fault current need not be provided for:

- (i) a conductor connecting a generator, transformer, rectifier or an accumulator battery to the associated control panel where the protective device is placed in the panel
- (ii) a circuit where disconnection could cause danger for the operation of the installation concerned, such as those quoted in 433.3.3
- (iii) certain measuring circuits
- (iv) the origin of an installation where the distributor installs one or more devices providing protection against fault current and agrees that such a device affords protection to the part of the installation between the origin and the main distribution point of the installation where further protection against fault current is provided,

provided that both of the following conditions are simultaneously fulfilled:

- (a) The wiring is carried out in such a way as to reduce the risk of fault to a minimum (see item (ii) of 434.2.1), and
- (b) the wiring is installed in such a manner as to reduce to a minimum the risk of fire or danger to persons.

#### **434.4 Fault current protection of conductors in parallel**

A single protective device may protect conductors in parallel against the effects of fault currents provided that the operating characteristic of the device results in its effective operation should a fault occur at the most onerous position in one of the parallel conductors. Account shall be taken of the sharing of the fault currents between the parallel conductors. A fault can be fed from both ends of a parallel conductor.

If operation of a single protective device may not be effective then one or more of the following measures shall be taken:

- (i) The wiring shall be installed in such a manner as to reduce to a minimum the risk of a fault in any parallel conductor, for example, by the provision of protection against mechanical damage. In addition, conductors shall be installed in such a manner as to reduce to a minimum the risk of fire or danger to persons
- (ii) For two conductors in parallel, a fault current protective device shall be provided at the supply end of each parallel conductor
- (iii) For more than two conductors in parallel, a fault current protective device shall be provided at the supply and load ends of each parallel conductor.

**NOTE:** Further information is given in paragraph 3 of Appendix 1.

#### **434.5 Characteristics of a fault current protective device**

Every fault current protective device shall meet the requirements of this .

**434.5.1** Except where the following paragraph applies, the rated short-circuit breaking capacity of each device shall be not less than the maximum prospective fault current at the point at which the device is installed.

A lower breaking capacity is permitted if another protective device or devices having the necessary rated short-circuit breaking capacity is installed on the supply side. In this situation, the characteristics of the devices shall be co-ordinated so that the energy let-through of these devices does not exceed that which can be withstood, without damage, by the device(s) on the load side.

**NOTE:** Technical data for the selection of protective devices can be requested from the manufacturer.

**434.5.2** A fault occurring at any point in a circuit shall be interrupted within a time such that the fault current does not cause the permitted limiting temperature of any conductor or cable to be exceeded.

For a fault of very short duration (less than 0.1 sec), for current limiting devices  $k^2S^2$  shall be greater than the value of let-through energy ( $I^2t$ ) quoted for the Class of protective device to KS IEC 60898-1, KS IEC 60898-2 or KS IEC 61009-1, or as quoted by the manufacturer.

The time,  $t$ , in which a given fault current will raise the live conductors from the highest permissible temperature in normal duty to the limiting temperature, can, as an approximation, be calculated from the formula:

$$t = \frac{k^2 S^2}{I^2}$$

where:

- $t$  is the duration in seconds
- $S$  is the cross-sectional area of conductor in  $\text{mm}^2$
- $I$  is the effective fault current, in amperes, expressed for AC as the rms value, due account being taken of the current limiting effect of the circuit impedances
- $k$  is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures. For common materials, the values of  $k$  are shown in Table 43.1.

**TABLE 43.1 –  
Values of k for common materials, for calculation of the effects of fault  
current for disconnection times up to 5 seconds**

	Conductor insulation							
	Thermoplastic				Thermosetting		Mineral insulated	
	90°C		70°C		90°C	60°C	Thermo plastic sheath	Bare(uns heathed)
Conductor cross-sectional area	≤ 300 mm <sup>2</sup>	> 300 mm <sup>2</sup>	≤ 300 mm <sup>2</sup>	> 300 mm <sup>2</sup>				
Initial temperature	90 °C		70 °C		90 °C	60 °C	70 °C	105 °C
Final temperature	160 °C	140 °C	160 °C	140 °C	250 °C	200 °C	160 °C	250 °C
Copper conductor	k = 100	k = 86	k = 115	k = 103	k = 143	k = 141	k = 115	k = 135/115 <sup>a</sup>
Aluminum conductor	k = 66	k = 57	k = 76	k = 68	k = 94	k = 93		
Tin soldered joints in copper conductors	k = 100	k = 86	k = 115	k = 103	k = 100	k = 122		

<sup>a</sup> This value shall be used for bare cables exposed to touch.

**NOTE 1:** The rated current or current setting of the fault current protective device may be greater than the current-carrying capacity of the cable.

**NOTE 2:** Other values of k can be determined by reference to IEC 60949:1988.

**434.5.3** For a busbar trunking system complying with KS IEC 61439-6 or a powertrack system complying with IEC 61534, one of the following requirements shall apply:

- (i) The rated short-time withstand current ( $I_{cw}$ ) and the rated peak withstand current of a busbar trunking system or powertrack system shall be not lower than the rms value of the prospective fault current and the prospective fault peak current value, respectively. The maximum time for which the  $I_{cw}$  is defined for the busbar trunking system shall be greater than the maximum operating time of the protective device
- (ii) The rated conditional short-circuit current of the busbar trunking system or powertrack system associated with a specific protective device shall be not lower than the prospective fault current.

## **435 CO-ORDINATION OF OVERLOAD CURRENT AND FAULT CURRENT PROTECTION**

### **435.1 Protection afforded by one device**

A protective device providing protection against both overload current and fault current shall fulfil the requirements in Sections 433 and 434.

Except as required by 434.4 or 434.5.2, where an overload protective device complying with 433.1 is to provide fault current protection and has a rated short-circuit breaking capacity not less than the value of the maximum prospective fault current at its point of installation, it may be assumed that the requirements of this section are satisfied as regards fault current protection of the conductors on the load side of that point.

The validity of the assumption shall be checked, where there is doubt, for conductors in parallel and for certain types of circuit-breaker e.g. non-current-limiting types.

#### **435.2 Protection afforded by separate devices**

The requirements of Sections 433 and 434 apply, respectively, to the overload current protective device and the fault current protective device.

The characteristics of the devices shall be co-ordinated so that the energy let through by the fault current protective device does not exceed that which can be withstood without damage by the overload protective device (see 536.1). This requirement does not exclude the type of co-ordination specified in KS IEC 60947-4-1. For a circuit incorporating a motor starter, this requirement does not preclude the type of co-ordination described in KS IEC 60947-4-1, in respect of which the advice of the manufacturer of the starter shall be sought.

#### **436 LIMITATION OF OVERCURRENT BY THE CHARACTERISTICS OF THE SUPPLY**

Conductors are considered to be protected against overload current and fault current where they are supplied from a source incapable of supplying a current exceeding the current-carrying capacity of the conductors (e.g. certain bell transformers, certain welding transformers and certain types of thermoelectric generating set).

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**CHAPTER 44**  
**PROTECTION AGAINST VOLTAGE DISTURBANCES AND**  
**ELECTROMAGNETIC DISTURBANCES**  
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**PROTECTION AGAINST VOLTAGE DISTURBANCES****440 INTRODUCTION****440.1 Scope**

These requirements are intended to provide for the safety of electrical installations in the event of voltage disturbances and electromagnetic disturbances generated due to different specified causes.

The requirements are not intended to apply to systems for distribution of energy to the public, or to power generation and transmission for such systems, although such disturbances may be conducted into or between electrical installations via these supply systems. The requirements of this chapter are in addition to those of Chapter 43.

**440.2 General**

This chapter covers the protection of electrical installations and measures against voltage disturbances and electromagnetic disturbances. The requirements are arranged into four sections as follows:

- (i) Section 442 Protection of low voltage installations against temporary overvoltages due to earth faults in the high voltage system and due to faults in the low voltage system
- (ii) Section 443 Protection against overvoltages of atmospheric origin or due to switching
- (iii) Section 444 Measures against electromagnetic disturbances
- (iv) Section 445 Protection against undervoltage.

**441 NOT USED****442 PROTECTION OF LOW VOLTAGE INSTALLATIONS AGAINST TEMPORARY OVERVOLTAGES DUE TO EARTH FAULTS IN THE HIGH VOLTAGE SYSTEM AND DUE TO FAULTS IN THE LOW VOLTAGE****442.1 Scope and object**

This provides requirements for the safety of the low voltage installation in the event of:

- (i) a fault between the high voltage system and Earth in the transformer substation that supplies the low voltage installation
- (ii) loss of the supply neutral in the low voltage system
- (iii) short-circuit between a line conductor and neutral in the low voltage installation
- (iv) accidental earthing of a line conductor of a low voltage IT system.

**442.1.1 General**

Section 442 gives rules for the designer and installer of the substation. It is necessary to have the following information on the high voltage system:

- (i) Quality of the system earthing
- (ii) Maximum level of earth fault current
- (iii) Resistance of the earthing arrangement.

The following s consider four situations which generally cause the most severe temporary overvoltages:

- (iv) Fault between the high voltage system(s) and Earth (see 442.2)
- (v) Loss of the neutral in a low voltage system (see 442.3)
- (vi) Accidental earthing of a low voltage IT system (see 442.4)
- (vii) Short-circuit in the low voltage installation (see 442.5).

## 442.1.2 Symbols

In Section 442 the following symbols are used (see Figure 44.1):

- $I_E$  part of the earth fault current in the high voltage system that flows through the earthing arrangement of the transformer substation
- $R_E$  resistance of the earthing arrangement of the transformer substation
- $R_A$  resistance of the earthing arrangement of the exposed-conductive-parts of the equipment of the low voltage installation
- $R_B$  resistance of the earthing arrangement of the low voltage system neutral, for low voltage systems in which the earthing arrangements of the transformer substation and of the low voltage system neutral are electrically independent
- $U_0$  in TN and TT systems: nominal AC rms line voltage to Earth  
in IT systems: nominal AC rms voltage between line conductor and neutral conductor or midpoint conductor, as appropriate
- $U_f$  power frequency fault voltage that appears in the low voltage system between exposed-conductive-parts and Earth for the duration of the fault
- $U_1$  power frequency stress voltage between the line conductor and the exposed-conductive-parts of the low voltage equipment of the transformer substation during the fault
- $U_2$  power frequency stress voltage between the line conductor and the exposed-conductive-parts of the equipment of the low voltage installation during the fault.

**NOTE 1:** The power frequency stress voltages ( $U_1$  and  $U_2$ ) are the voltages that appear across the insulation of low voltage equipment and across surge protective devices connected to the low voltage system.

The following additional symbols are used in respect of IT systems in which the exposed-conductive-parts of the equipment of the low voltage installation are connected to an earthing arrangement that is electrically independent of the earthing arrangement of the transformer substation.

- $I_h$  the fault current that flows through the earthing arrangement of the exposed-conductive-parts of the equipment of the low voltage installation during a period when there is a high voltage fault and a first fault in the low voltage installation (see Table 44.1)
- $I_d$  the fault current, in accordance with 411.6.2, that flows through the earthing arrangement of the exposed-conductive-parts of the low voltage installation during the first fault in a low voltage system (see Table 44.1)
- $Z$  is the impedance (for example, the IMD internal impedance or the artificial neutral impedance) between the low voltage system and an earthing arrangement.

**NOTE 2:** An earthing arrangement may be considered electrically independent of another earthing arrangement if a rise of potential with respect to Earth in one earthing arrangement does not cause an unacceptable rise of potential with respect to Earth in the other earthing arrangement.

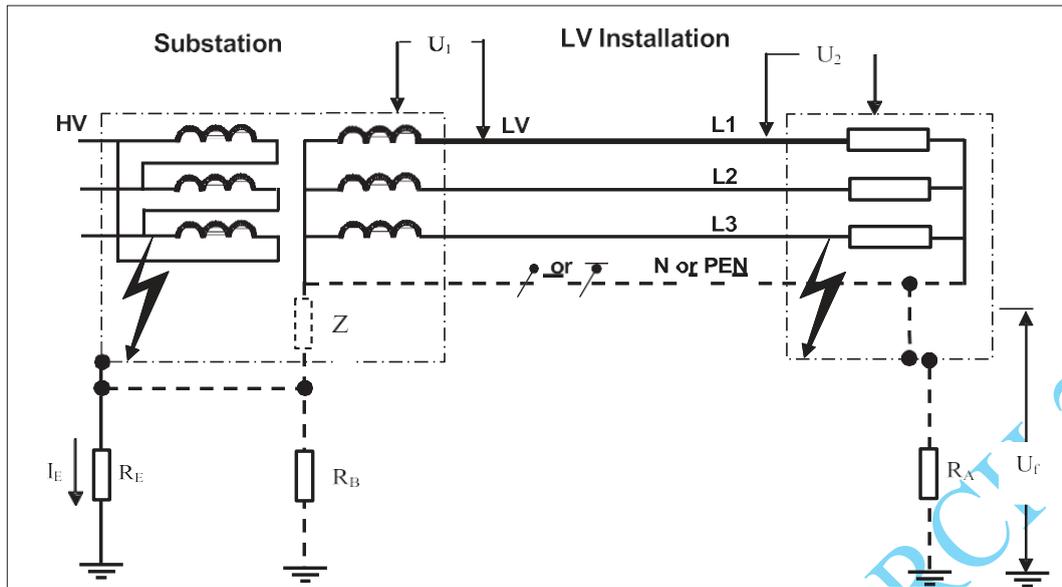
## 442.2 Overvoltages in low voltage (LV) systems during a high voltage (HV) earth fault

In case of a fault to Earth in the HV side of the substation the following types of overvoltage may affect the LV installation:

- (i) Power frequency fault voltage ( $U_f$ )
- (ii) Power frequency stress voltages ( $U_1$  and  $U_2$ ).

Table 44.1 provides the relevant methods of calculation for the different types of overvoltage.

**Fig 44.1 – Representative diagram for connections to Earth in the substation and the LV installation and the overvoltages occurring in case of faults**



Where high and low voltage earthing systems exist in proximity to each other, two practices are presently used:

- interconnection of all high voltage ( $R_E$ ) and low voltage ( $R_B$ ) earthing systems
- separation of high voltage ( $R_E$ ) from low voltage ( $R_B$ ) earthing systems.

The general method used is interconnection. The high and low voltage earthing systems shall be interconnected if the low voltage system is totally confined within the area covered by the high voltage earthing system (see KS IEC 61936).

**NOTE 1:** Details of the different types of system earthing are shown in KS 662-3.

**NOTE 2:** KS IEC 61936, Table 2, gives minimum requirements for determining whether it is feasible to interconnect high voltage and low voltage earthing arrangements. Feasibility is dependent on the earthing design for the substation achieving minimum safe touch and step voltages and a tolerable 'earth potential rise' (EPR - stress voltage).

**TABLE 44.1 – Power frequency stress voltages and power frequency fault voltage in the low voltage system**

Type of system earthing	Type of earth connections	$U_1$	$U_2$	$U_f$
TT	$R_E$ and $R_B$ connected	$U_0$	$R_E \times I_E + U_0$	0 *
	$R_E$ and $R_B$ separated	$R_E \times I_E + U_0$	$U_0$ *	0 *
TN	$R_E$ and $R_B$ connected	$U_0$	$U_0$ *	$R_E \times I_E$ **
	$R_E$ and $R_B$ separated	$R_E \times I_E + U_0$	$U_0$ *	0 *
IT	$R_E$ and Z connected	$U_0$	$R_E \times I_E + U_0$	0 *
	$R_E$ and $R_A$ separated †	$U_0 \times \sqrt{3}$	$R_E \times I_E + U_0 \times \sqrt{3}$	$R_A \times I_h$
	$R_E$ and Z connected	$U_0$	$U_0$	$R_E \times I_E$
	$R_E$ and $R_A$ interconnected †	$U_0 \times \sqrt{3}$	$U_0 \times \sqrt{3}$	$R_E \times I_E$
	$R_E$ and Z separated	$R_E \times I_E + U_0$	$U_0$ *	0 *
	$R_E$ and $R_A$ separated †	$R_E \times I_E + U_0 \times \sqrt{3}$	$U_0 \times \sqrt{3}$	$R_A \times I_d$

† With existing earth fault in the installation.

\* No consideration need be given

\*\* See 442.2.1

**NOTE 1:** The requirements for  $U_1$  and  $U_2$  are derived from design criteria for insulation of low voltage equipment with regard to temporary power frequency overvoltage (see also Table 44.2).

**NOTE 2:** In a system whose neutral is connected to the earthing arrangement of the transformer substation, such temporary power frequency overvoltage is also to be expected across insulation which is not in an earthed enclosure where the equipment is outside a building.

**NOTE 3:** In TT and TN systems the terms 'connected' and 'separated' refer to the electrical connection between  $R_E$  and  $R_B$ . For IT systems the terms refer to the electrical connection between  $R_E$  and  $Z$  and the connection between  $R_E$  and  $R_A$ .

#### 442.2.1 Power frequency fault voltage

The fault voltage  $U_f$  as calculated in Table 44.1, which appears in the low voltage installation between exposed- conductive-parts and Earth, shall not exceed a dangerous level.

**NOTE 1:** In a TN system where  $R_E$  and  $R_B$  are connected together (see Table 44.1), their connection to a low voltage global earthing system as described in IEC 61936, clause 10, can be considered to be a safety measure against dangerous fault voltages.

**NOTE 2:** A global earthing system is an earthing system created by the interconnection of local earthing systems that provides, by the proximity of these earthing systems, that there are no dangerous touch voltages.

In installations outside a global earthing system, additional connection shall be made between the PEN conductor and Earth.

#### 442.2.2 Magnitude and duration of power frequency stress voltages

The magnitude and duration of the power frequency stress voltages ( $U_1$  and  $U_2$ ), where specified in Table 44.1, on the equipment in the low voltage installation due to an earth fault in the high voltage system, shall not exceed the requirements given in Table 44.2.

**TABLE 44.2 – Permissible power frequency stress voltage**

Duration of the earth fault in the high voltage system t	Permissible power frequency stress voltage on equipment in low voltage installations U
> 5 s	$U_0 + 250 \text{ V}$
$\leq 5 \text{ s}$	$U_0 + 1200 \text{ V}$

In systems without a neutral conductor,  $U_0$  shall be the line-to-line voltage.

**NOTE 1:** The first line of the table relates to high voltage systems having long disconnection times, for example, isolated neutral and resonant earthed high voltage systems. The second line relates to high voltage systems having short disconnection times, for example, low-impedance earthed high voltage systems. Both lines together are relevant design criteria for insulation of low voltage equipment with regard to temporary power frequency overvoltage, IEC 60664-1.

**NOTE 2:** In a system whose neutral is connected to the earthing arrangement of the transformer substation, such temporary power frequency overvoltage is also to be expected across insulation which is not in an earthed enclosure where the equipment is outside a building.

#### 442.2.3 Requirements for calculation of limits

The requirements of s 442.2.1 and 442.2.2 are deemed to be fulfilled for installations receiving a supply at low voltage from a system for distribution of electricity to the public.

To fulfil the above requirements co-ordination between the HV system operator and the LV system installer is necessary. Compliance with the above requirements mainly falls into the responsibility of the substation installer/owner/ operator who needs also to fulfil requirements provided by KS IEC 61936-1. Therefore, the calculation for  $U_1$ ,  $U_2$  and  $U_f$  is normally not necessary for the LV system installer.

Possible measures to fulfil the above requirements are, for example:

- (i) separation of HV and LV earthing arrangements
- (ii) change of LV system earthing
- (iii) reduction of earth resistance,  $R_E$ .

#### 442.3 Power frequency stress voltage in the event of loss of the neutral conductor in TN or TT system

Consideration shall be given to the fact that, if the neutral conductor in a three-phase TN or TT system is interrupted, basic, double and reinforced insulation as well as components rated for the voltage between line and neutral conductors can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to  $U = \sqrt{3} U_0$ .

#### **442.4 Power frequency stress voltage in the event of an earth fault in a IT system with distributed neutral**

Consideration shall be given to the fact that, if a line conductor of an IT system is earthed accidentally, insulation or components rated for the voltage between line and neutral conductors can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to  $U = \sqrt{3} U_0$ .

#### **442.5 Power frequency stress voltage in the event of short-circuit between a line conductor and the neutral conductor**

Consideration shall be given to the fact that, if a short-circuit occurs in the low voltage installation between a line conductor and the neutral conductor, the voltage between the other line conductors and the neutral conductor can reach the value of  $1.45 \times U_0$  for a time up to 5s.

### **443 PROTECTION AGAINST TRANSIENT OVERVOLTAGES OF ATMOSPHERIC ORIGIN OR DUE TO SWITCHING**

#### **443.1 Scope and object**

**443.1.1** This section deals with protection of electrical installations against transient overvoltages of atmospheric origin transmitted by the supply distribution system, including direct strikes to the supply system, and against switching overvoltages generated by the equipment within the installation.

This section does not specify requirements for protection against transient overvoltages due to direct or nearby lightning strokes on the structure.

**NOTE 1:** For risk management for protection against transient overvoltages due to direct or nearby lightning strokes on the structure, see KS IEC 62305-2.

In general, switching overvoltages have lower amplitude than transient overvoltages of atmospheric origin and therefore the requirements regarding protection against transient overvoltages of atmospheric origin normally cover protection against switching overvoltages.

If no transient overvoltage protection against disturbances of atmospheric origin is installed, protection against switching overvoltages may need to be provided.

**NOTE 2:** Overvoltages due to switching can be longer in duration and can contain more energy than transient overvoltages of atmospheric origin (see 443.4).

**NOTE 3:** The characteristics of transient overvoltages of atmospheric origin depend on factors such as:

- the nature of the supply distribution system (underground or overhead)
- the possible existence of at least one surge protective device (SPD) upstream of the installation
- the voltage level of the supply system.

**NOTE 4:** Transient overvoltages transmitted by the supply distribution system are not significantly attenuated downstream in most installations.

This section does not cover overvoltages transmitted by Information, Control and Telecommunications (ICT) systems. See IEC 60364-5-52, KS IEC 62305-4 and IEC 61643-22.

**NOTE 5:** As regards transient overvoltages of atmospheric origin, no distinction is made between earthed and unearthed systems.

Where protection against overvoltages is by the use of surge protective devices (SPDs) they shall be selected and erected in accordance with Section 534.

**NOTE 6:** Examples of equipment with various rated impulse voltages are given in Table 443.2.

**NOTE 7:** Some electronic equipment may have protection levels lower than Category I of Table 443.2.

This section does not apply to installations where the consequences of overvoltage are:

- (a) explosion
- (b) chemical or radioactive emissions.

**NOTE 8:** KS IEC 62305-2 applies for such high-risk installations.

**443.2** *Not used*

**443.3** *Not used*

#### 443.4 Overvoltage control

Protection against transient overvoltages shall be provided where the consequence caused by overvoltage could:

- (i) result in serious injury to, or loss of, human life, or
- (ii) result in interruption of public services and/or damage to cultural heritage, or
- (iii) result in interruption of commercial or industrial activity, or
- (iv) affect a large number of co-located individuals.

For all other cases, a risk assessment according to 443.5 shall be performed in order to determine if protection against transient overvoltages is required. If the risk assessment is not performed, the electrical installation shall be provided with protection against transient overvoltages, except for single dwelling units where the total value of the installation and equipment therein does not justify such protection.

Protection against switching overvoltages shall be considered in the case of equipment likely to produce switching overvoltages or disturbances exceeding the values according to the overvoltage category of the installation, e.g. where an LV generator supplies the installation or where inductive or capacitive loads (e.g. motors, transformers, capacitor banks), storage units or high-current loads are installed.

#### 443.5 Risk assessment method

Refer to KS IEC 62305-2

#### 443.6 Classification of rated impulse voltages (overvoltage categories)

##### 443.6.1 Purpose of classification of rated impulse voltages (overvoltage categories)

Overvoltage categories are defined within electrical installations for the purpose of insulation coordination and a related classification of equipment with rated impulse voltages is provided (see Table 443.2).

The rated impulse voltage is used to classify equipment energized directly from the low voltage electrical installation into overvoltage categories.

Rated impulse voltages for equipment selected according to the nominal voltage are provided to distinguish different levels of availability of equipment with regard to continuity of service and an acceptable risk of failure.

Inherent overvoltage control for insulation coordination, based only on the rated impulse voltage of the equipment in accordance with IEC 60664-1, is not sufficient where:

- transient overvoltages transmitted via the supply distribution system are not significantly attenuated downstream

**NOTE:** Insulation coordination can be achieved in the whole installation by transient overvoltage protection of the equipment corresponding to the classified rated impulse voltage, thereby reducing the risk of failure to an acceptable level.

- surge currents and partial lightning currents are distributed via underground cables
- equipment is connected to multiple services, e.g. power, telecommunications and data lines.

It is necessary to consider the rated impulse voltage  $U_w$  (see IEC 60664-1) of the most sensitive equipment to be protected in the system or, in cases where a temporary loss of function of equipment is unacceptable, the impulse immunity voltage (see IEC 61000-4-5).

##### 443.6.2 Rated impulse voltages of equipment and overvoltage categories

Category IV equipment is suitable for use at, or in the proximity of, the origin of the electrical installation, for example, upstream of the main distribution board. Equipment of category IV has a very high impulse withstand capability providing the required high degree of reliability and shall have a rated impulse voltage not less than the value specified in Table 443.2.

Category III equipment is suitable for use in the fixed installation downstream of and including the main distribution board, providing a high degree of availability, and shall have a rated impulse voltage not less than the value specified in Table 443.2.

Category II equipment is suitable for connection to the fixed installation, providing a degree of availability normally required for current-using equipment, and shall have a rated impulse voltage not less than the value specified in Table 443.2.

Category I equipment is only suitable for use in the fixed installation where SPDs are installed outside the equipment to limit transient overvoltages to the specified level, and shall have a rated impulse voltage not less than the value specified in Table 443.2. Therefore, equipment with a rated impulse voltage corresponding to overvoltage category I should, preferably, not be installed at or near the origin of the installation.

**Table 443.2 – Required rated impulse voltage of equipment (Uw)**

Nominal voltage of the installation V <sup>a</sup>	Voltage line to neutral derived from nominal voltages AC or DC up to and including V	Required rated impulse voltage of equipment <sup>b</sup> kV			
		Overvoltage category IV (equipment with very high rated impulse voltage)	Overvoltage category III (equipment with high rated impulse voltage)	Overvoltage category II (equipment with normal rated impulse voltage)	Overvoltage category I (equipment with reduced rated impulse voltage)
		For example, energy meter, telecontrol systems	For example, distribution boards, switches socket-outlets	For example, domestic appliances, tools	For example, sensitive electronic equipment such as alarm panels, computers and home electronics
120/208	150	4	2.5	1.5	0.8
230/400 <sup>c</sup> 277/480	300	6	4	2.5	1.5
400/690	600	8	6	4	2.5
1000	1000	12	8	6	4
1500 DC	1500 DC	-	-	-	-
<p>a According to KS IEC 60038</p> <p>b This rated impulse voltage is applied between live conductors and PE.</p> <p>c For IT systems operating at 220-240 V, the 230/400 row should be used, due to the voltage to earth at the earth fault on one line.</p>					

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## ANNEX B443 (Informative)

### GUIDANCE ON OVERVOLTAGE CONTROL BY SPDs APPLIED TO OVERHEAD LINES

Where an installation is supplied by, or includes, an overhead line and SPDs are required according to 443.4, the protective control of the overvoltage level may be obtained either by installing surge protective devices directly in the installation close to the origin of the installation or, with the consent of the network operator, in the overhead lines of the supply distribution network.

As an example, the following measures may be applied:

- (a) in the case of overhead supply distribution networks, overvoltage protection is erected at network junction points and especially at the end of each feeder longer than 0.5 km. Surge protective devices should be erected at every 0.5 km distance along the supply distribution lines. Nevertheless, the distance between surge protective devices should in no case exceed 1 km
- (b) if a supply distribution network is erected partly as an overhead network and partly as an underground network, overvoltage protection in the overhead lines should be applied in accordance with (a) at each transition point from an overhead line to an underground cable
- (c) in a TN distribution network supplying electrical installations, where the protective measure automatic disconnection of supply is applied, the earthing conductors of the surge protective devices connected to the line conductors are connected to the PEN conductor or to the PE conductor
- (d) in a TT distribution network supplying electrical installations, where the protective measure automatic disconnection of supply is applied, surge protective devices are provided for the line conductors and for the neutral conductor. At the place where the neutral conductor of the supply network is effectively earthed, a surge protective device for the neutral conductor is not necessary.

### 444 MEASURES AGAINST ELECTROMAGNETIC DISTURBANCES

#### 444.1 Scope

This section provides basic requirements and recommendations to enable the avoidance and reduction of electromagnetic disturbances.

Those involved in the design, installation and maintenance of, and alterations to, electrical installations shall give due consideration to the measures described in this section.

Electromagnetic disturbances can disturb or damage information technology systems or information technology equipment as well as equipment with electronic components or circuits. Currents due to lightning, switching operations, short-circuits and other electromagnetic phenomena might cause overvoltages and electromagnetic interference.

These effects are potentially more severe:

- (i) where large metal loops exist
- (ii) where different electrical wiring systems are installed in common routes, e.g. for power supply and for signalling and/or data communication cables connecting information technology equipment within a building.

The value of the induced voltage depends on the rate of change ( $di/dt$ ) of the interference current and on the size of the loop.

Power cables carrying large currents with a high rate of change of current ( $di/dt$ ) (e.g. the starting current of lifts or currents controlled by rectifiers) can induce overvoltages in cables of information technology systems, which can influence or damage information technology equipment or similar electrical equipment.

In or near rooms for medical use, electromagnetic disturbances associated with electrical installations can interfere with medical electrical equipment.

The requirements and recommendations given in this section can have an influence on the overall design of the building including its structural aspects.

The requirements of the following standards shall be applied where appropriate:

- (iii) ISO/IEC TS 29125: Information Technology-Telecommunications cabling requirements for remote powering of terminal equipment.

- (iv) ISO/IEC 30129: Application of equipotential bonding and earthing in buildings with information technology equipment.
- (v) IEC 60364-5-52 series: Information technology. Cabling installation
- (vi) IEC 61000-5-2: Electromagnetic compatibility (EMC). Installation and mitigation guidelines. Earthing and cabling.

**444.2 Not used**

**444.3 Not used**

#### **444.4 Electromagnetic disturbances**

##### **444.4.1 Sources of electromagnetic disturbances**

Consideration shall be given to the location of the sources of electromagnetic disturbances relative to the positioning of other equipment. Potential sources of electromagnetic disturbances within an installation typically include:

- (i) switching devices for inductive loads
- (ii) electric motors
- (iii) fluorescent lighting
- (iv) welding machines
- (v) rectifiers
- (vi) choppers
- (vii) frequency convertors/regulators including Variable Speed Drives (VSDs)
- (viii) lifts
- (ix) transformers
- (x) switchgear
- (xi) power distribution busbars.

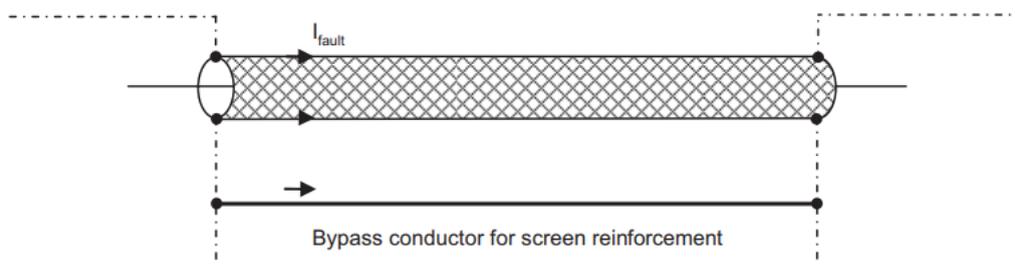
**NOTE:** For further information refer to the IEC 60364-5-52 series of standards.

##### **444.4.2 Measures to reduce EMI**

**444.4.2.1** The following measures shall be considered, where appropriate, in order to reduce the effects of electromagnetic interference:

- (i) Where screened signal or data cables are used, care should be taken to limit the fault current from power systems flowing through the screens and cores of signal cables, or data cables, which are earthed. Additional conductors may be necessary, e.g. a bypass conductor for screen reinforcement, see Figure 44.4

**Fig 44.4 – Bypass conductor for screen reinforcement to provide a common equipotential bonding system**



- (ii) The use of surge protective devices and/or filters to improve electromagnetic compatibility with regard to conducted electromagnetic phenomena for electrical equipment sensitive to electromagnetic disturbances
- (iii) The installation of power cables (i.e. line, neutral and any protective earth conductors) close together in order to minimize cable loop areas
- (iv) The separation of power and signal cables
- (v) The installation of an equipotential bonding network, see 444.5.2.

##### **444.4.3 TN system**

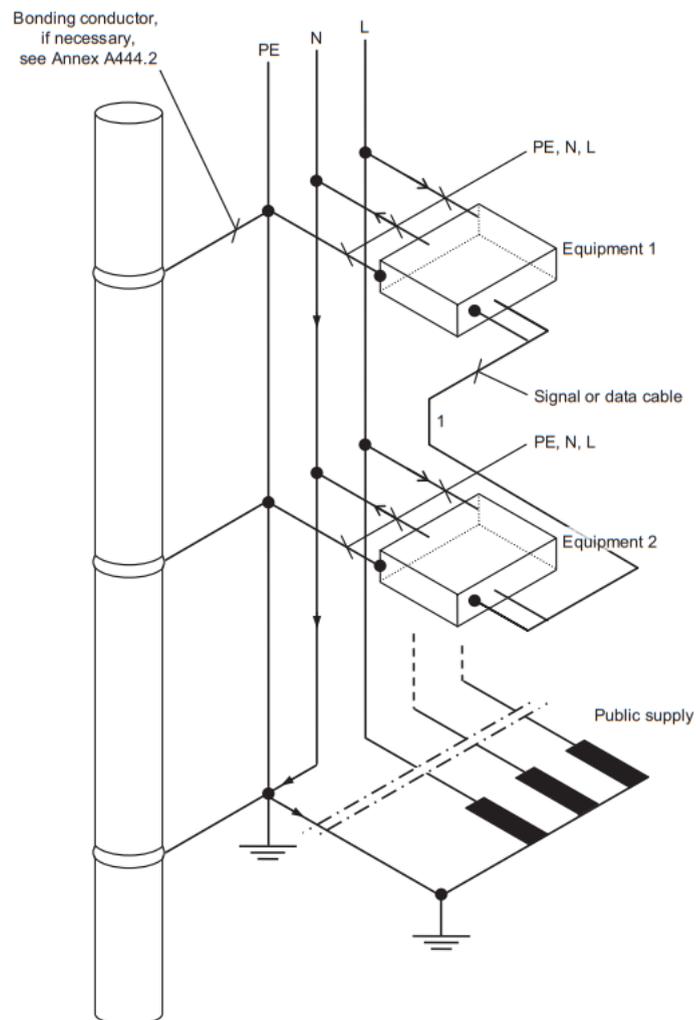
To minimize electromagnetic disturbances, the following requirements shall be met.

**444.4.3.1** A PEN conductor shall not be used downstream of the origin of the installation.

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**444.4.3.2** The installation shall have separate neutral and protective conductors downstream of the origin of the installation; see Figure 44.5.

**Fig 44.5 – Avoidance of neutral conductor currents in a bonded structure by using an installation forming part of a TN-C-S system from the origin of the public supply up to and including the final circuit within a building**

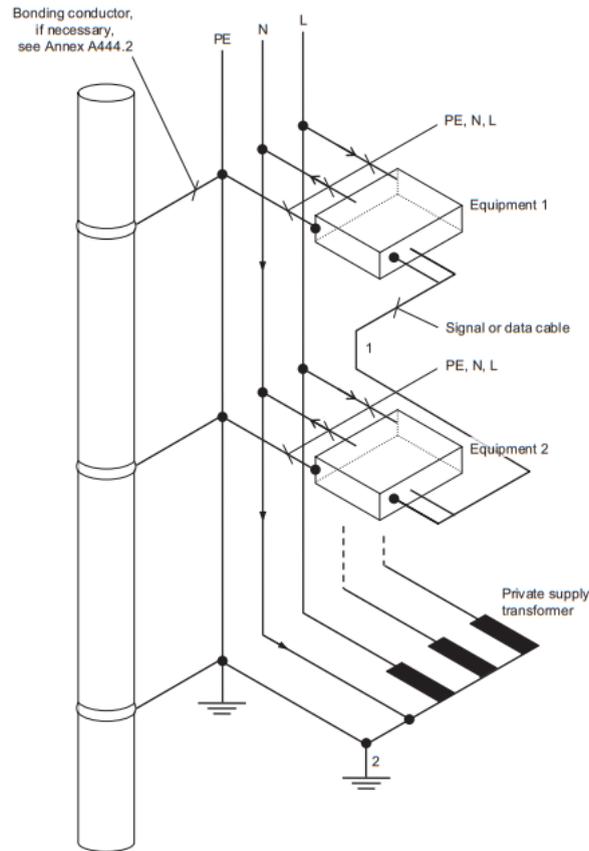


Key:

1 Loops of limited area formed by signal or data cables.

**444.4.3.3** Where the complete low voltage installation including the transformer is operated only by the user, an installation forming part of a TN-S system shall be installed; see Figure 44.6.

**Fig 44.6 – Avoidance of neutral conductor currents in a bonded structure by using an installation forming part of a TN-S system downstream of a consumer’s private supply transformer**



**Key:**

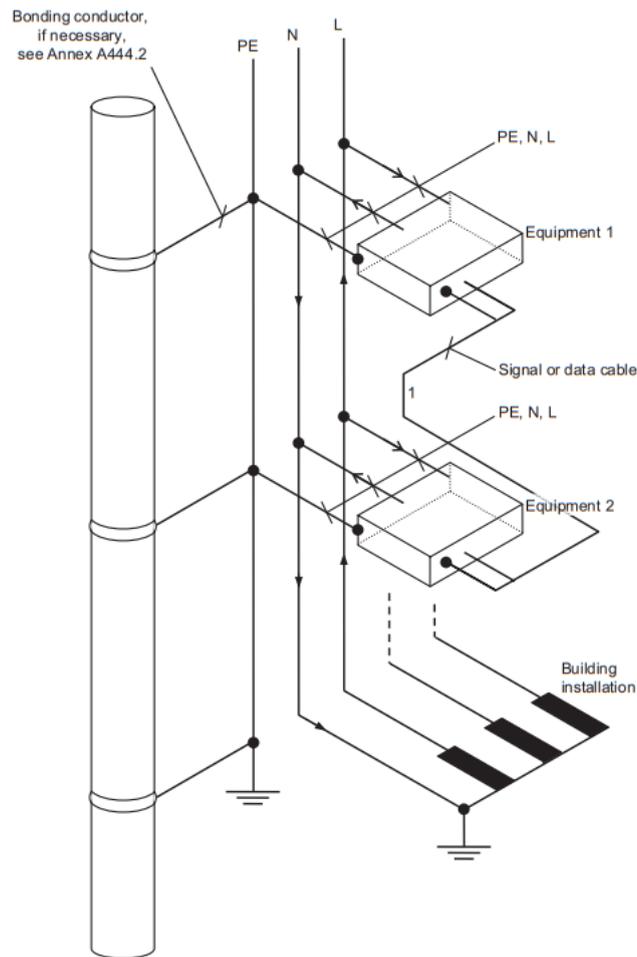
- 1 Loops of limited area formed by signal or data cables.
- 2 The point of neutral earthing may be made at the transformer or the main LV switchgear.

**444.4.4 TT system**

In an installation forming part of a TT system, such as that shown in Figure 44.7, consideration shall be given to overvoltages which might exist between live parts and extraneous-conductive-parts where the extraneous- conductive-parts of different buildings are connected to different earth electrodes.

The use of an isolating transformer to provide a TN-S system shall be considered.

**Fig 44.7 – Installation forming part of a TT system within a building installation**

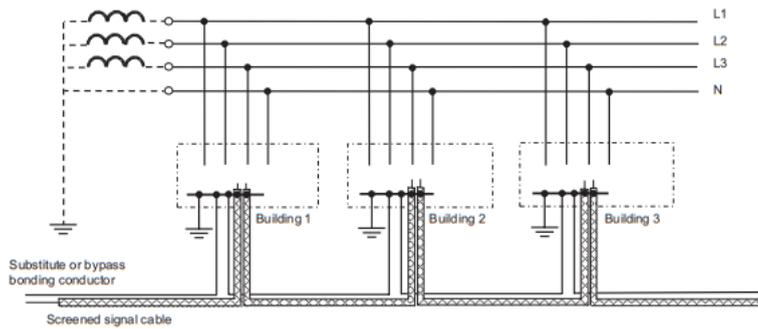


Key :1 Loops of limited area formed by signal or data cables.

Where screened signal cables or data cables are common to several buildings supplied from an installation forming part of a TT system, the use of a bypass bonding conductor (see Figure 44.8) or single-point bonding shall be considered. The bypass conductor shall have a minimum cross-sectional area of 16 mm<sup>2</sup> copper or equivalent, the equivalent cross-sectional area being selected in accordance with 544.1.

Where the live conductors of the supply into any of the buildings exceed 35 mm<sup>2</sup> in cross-sectional area the bypass conductor shall have a minimum cross-sectional area in accordance with Table 54.8.

**Fig 44.8 – Example of a substitute or bypass bonding conductor in an installation forming part of a TT system**



If consent according to the last paragraph of 411.3.1.2 (telecommunication cables) cannot be obtained, it is the responsibility of the owner or operator of the cable to avoid any danger due to the exclusion of those cables from the connection to the main equipotential bonding.

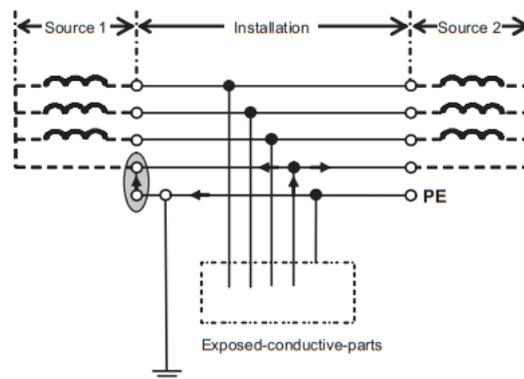
**444.4.5** Not used

**444.4.6 Multiple-source TN or TT power supplies**

For TN or TT multiple-source power supplies to an installation, the system shall be earthed at one point only.

For a TN system, to avoid having the neutral current flowing through the protective conductor, a single point of connection only shall be made as illustrated in Figure 44.9.

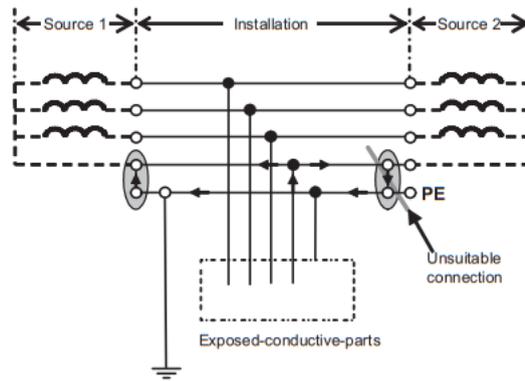
**Fig 44.9 – TN multiple-source power supply with single connection between PEN and earth**



**NOTE 1:** Where multiple earthing of the star points of the sources of supply is applied, neutral conductor currents might flow back to the relevant star point, not only via the neutral conductor, but also via the protective conductor as shown in Figure 44.10. For this reason the sum of the partial currents flowing in the installation is no longer zero and a stray magnetic field is created, similar to that of a single conductor cable.

**NOTE 2:** In the case of a single conductor cable carrying AC current, a circular electromagnetic field is generated around the conductor that might interfere with electronic equipment. Harmonic currents produce similar electromagnetic fields but they attenuate more rapidly than those produced by the fundamental current.

**Fig 44.10 – TN multiple-source power supply with unsuitable multiple connection between PEN and earth**



#### 444.4.7 Transfer of supply

In an installation forming part of a TN system the transfer from one supply to an alternative supply shall be by means of a multipole switching device which switches the line conductors and the neutral conductor, if any.

**NOTE:** This method prevents electromagnetic fields due to stray currents in the main supply system of an installation.

#### 444.4.8 Not used

#### 444.4.9 Separate buildings

Where different buildings have separate equipotential bonding systems, metal-free optical fibre cables or other non-conducting systems are preferred for signal and data transmission, e.g. microwave signal transformer for isolation in accordance with IEC 61558-2-1, IEC 61558-2-4, IEC 61558-2-6, KS IEC 61558-2-15 and KS IEC 62368-1.

#### 444.4.10 Inside buildings

Within a building, the requirements and recommendations of the following standards shall be applied for control, signalling and communication circuits:

- (i) IEC 61935-2, KS ISO/IEC 11801-1 and IEC 60364-1: Information technology – Cabling installation: Installation specification and quality assurance and Installation planning and practices inside buildings
- (ii) ISO/IEC 30129: Application of equipotential bonding and earthing in buildings with information technology equipment.

### 444.5 Earthing and equipotential bonding

#### 444.5.1 Interconnection of earth electrodes

##### 444.5.1.1 Within a single building

All protective and functional earthing conductors of an installation within a building shall be connected to the main earthing terminal, as required by 542.4.1, except where this is precluded by the requirements of legislation or Part 7.

##### 444.5.1.2 Between buildings

For communication and data exchange between several buildings, the requirements of 542.1.3.3 apply to both the protective and functional earthing requirements.

**NOTE:** Where interconnection of the earth electrodes is not possible or practicable, it is recommended that separation of communications networks is applied, for example, by using optical or radio links.

#### **444.5.2 Equipotential bonding networks**

The structure selected for these conductors shall be appropriate for the installation:

- (i) Metal sheaths, screens or armouring of cables shall be bonded to the common bonding network (CBN) unless such bonding is required to be omitted for safety reasons
- (ii) Where screened signal or data cables are earthed, care shall be taken to limit the fault current from power systems flowing through the screens and cores of signal cables or data cables
- (iii) The impedance of equipotential bonding connections intended to carry functional earth currents having high frequency components shall be as low as practicable and this should be achieved by the use of multiple, separated bonds that are as short as possible

**NOTE:** Where bonds of up to 1 metre long are used, their inductive reactance and impedance of route can be reduced by choosing a conductive braid or a bonding strap/strip (with a width to thickness ratio of at least 5:1 and a length to width ratio no greater than 5:1).

- (iv) Where a lightning protection system is installed, reference shall be made to KS IEC 62305.

#### **444.5.3 Sizing and installation of copper bonding ring network conductors**

Equipotential bonding designed as a bonding ring network shall have the following minimum nominal dimensions:

- (i) Flat cross-section: 25 mm × 3 mm
- (ii) Round diameter: 8 mm.

Bare conductors shall be protected against corrosion at their supports and on their passage through walls.

##### **444.5.3.1 Parts to be connected to the equipotential bonding network**

The following parts shall be connected to the equipotential bonding network:

- (i) Metallic containment, conductive screens, conductive sheaths or armouring of data transmission cables or of information technology equipment
- (ii) Functional earthing conductors of antenna systems
- (iii) Conductors of the earthed pole of a DC supply for information technology equipment
- (iv) Functional earthing conductors
- (v) Protective conductors.

**444.5.4** *Not used*

**444.5.5** *Not used*

**444.5.6** *Not used*

#### **444.5.7 Earthing arrangements and equipotential bonding of information technology installations for functional purposes**

##### **444.5.7.1 Earthing busbar**

Where an earthing busbar is required for functional purposes, consideration shall be given to extending the main earthing terminal of the building by using one or more earthing busbars. This enables information technology installations to be connected to the main earthing terminal by the shortest practicable route from any point in the building. Where the earthing busbar is erected to support the equipotential bonding network of a significant amount of information technology equipment in a building, consideration shall be given to the installation of a bonding ring conductor or common mesh bonding network; see Annex A444 Figure A444.2.

Consideration shall be given to the need for accessibility of the earthing busbar throughout its length and to the protection of bare conductors to prevent corrosion.

##### **444.5.7.2 Cross-sectional area of the earthing busbar**

For installations connected to a supply having a capacity of 200 A per phase or more, the cross-sectional area of the earthing busbar shall be not less than 50 mm<sup>2</sup> copper and shall be selected in accordance with 444.5.2(iii).

For supplies having a capacity of less than 200 A per phase the earthing busbar shall be selected in accordance with Table 54.8.

Where the earthing busbar is used as part of a DC return current path, its cross-sectional area shall be selected according to the expected DC return currents.

## **444.6 Segregation of circuits**

### **444.6.1 General**

Cables that are used at voltage Band II (low voltage) and cables that are used at voltage Band I (extra-low voltage) which share the same cable management system or the same route, shall be installed according to the requirements of s 528.1 and 528.2. Circuits of the same voltage band might also require segregation or separation.

Electrical safety and electromagnetic compatibility might produce different segregation or separation requirements. The design shall meet both requirements.

### **444.6.2 Equipment**

The minimum distance between information technology cables and discharge, neon and mercury vapour (or other high-intensity discharge) lamps shall be 130 mm. In this regard, low energy lamps (cfl) are to be considered as gas discharge sources. Data wiring racks and electrical equipment shall always be separated.

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# ANNEX A444 (Informative)

## MEASURES AGAINST ELECTROMAGNETIC DISTURBANCES

### A444.1 Structures for the network of bonding conductors and earthing conductors

For dwellings, where normally a limited amount of electronic equipment is in use, a protective conductor network in the form of a star network might be acceptable.

For commercial and industrial buildings and similar buildings containing multiple electronic applications, a common equipotential bonding system is useful in order to comply with the EMC requirements of different types of equipment.

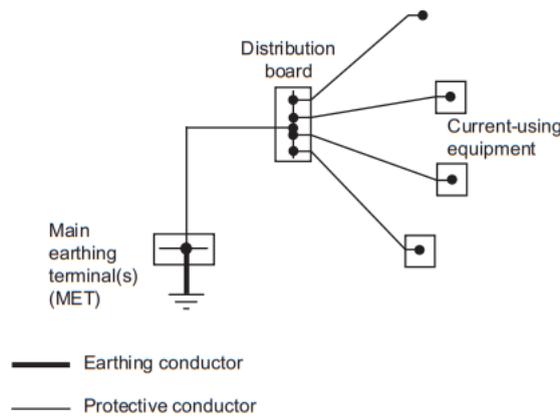
The four basic structures described as follows might be used, depending on the importance and vulnerability of equipment.

**NOTE:** For further information, the methodology referred to in ISO/IEC 30129 (The application of equipotential bonding and earthing in buildings with information technology equipment) is generally applicable.

#### A444.1.1 Protective conductors in a star network

This type of network is applicable to small installations associated with dwellings, small commercial buildings, etc., and from a general point of view to equipment that is not interconnected by signal cables; see Figure A444.1.

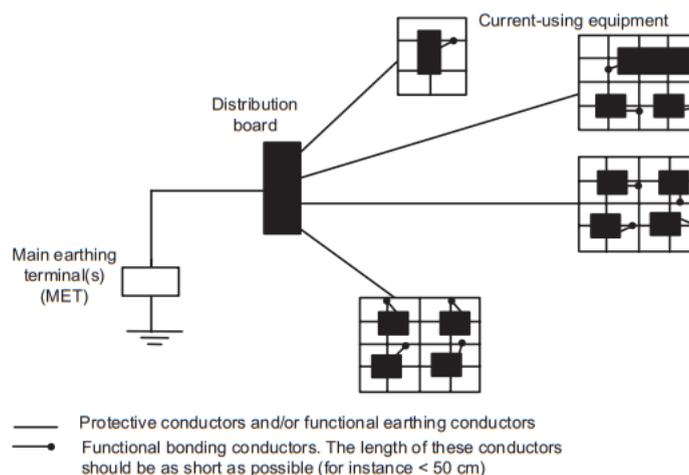
**Fig A444.1 – Example of protective conductors in star network**



#### A444.1.2 Multiple meshed bonding star network

This type of network is applicable to small installations with different small groups of interconnected communicating equipment. It enables the local dispersion of currents caused by electromagnetic interference; see Figure A444.2.

**Fig A444.2 – Example of multiple meshed bonding star network**



### A444.1.3 Common meshed bonding star network

This type of network is applicable to installations with a high density of communicating equipment corresponding to critical applications; see Figure A444.3. It is suitable for protection of private automatic branch exchange equipment (PABX) and centralized data processing systems.

A meshed equipotential bonding network is enhanced by the existing metallic structure of the building. It is supplemented by conductors forming the square mesh.

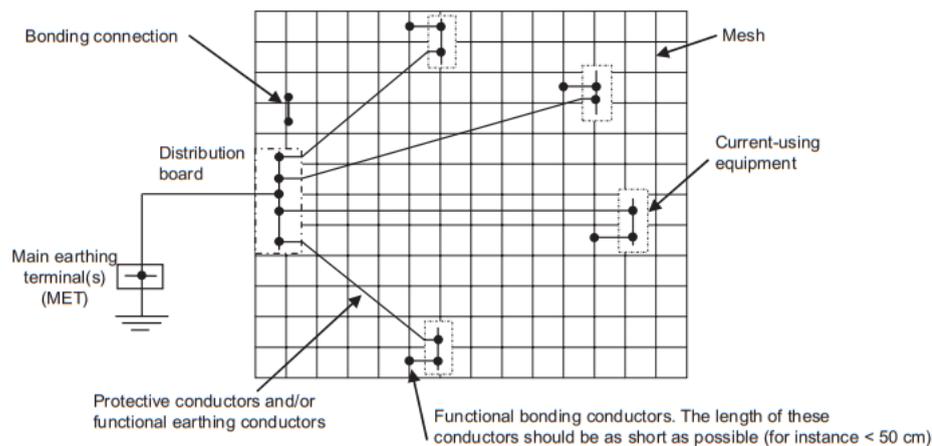
The mesh size depends on the selected level of protection against lightning, on the immunity level of the equipment and on the frequencies used for data transmission.

Mesh size should be adapted to the dimensions of the installation to be protected and should be in accordance with the recommendations of ISO/IEC 30129. Where concerns exist, the mesh size should be adapted to the dimensions of the installation to be protected, but should not exceed 2 m × 2 m in areas where equipment susceptible to electromagnetic environmental interferences is installed.

**NOTE:** The mesh size refers to the dimensions of square spaces enclosed by the conductors forming the mesh.

In some cases, parts of this network may be meshed more closely in order to meet specific requirements.

Fig A444.3 – Example of a common meshed bonding star network



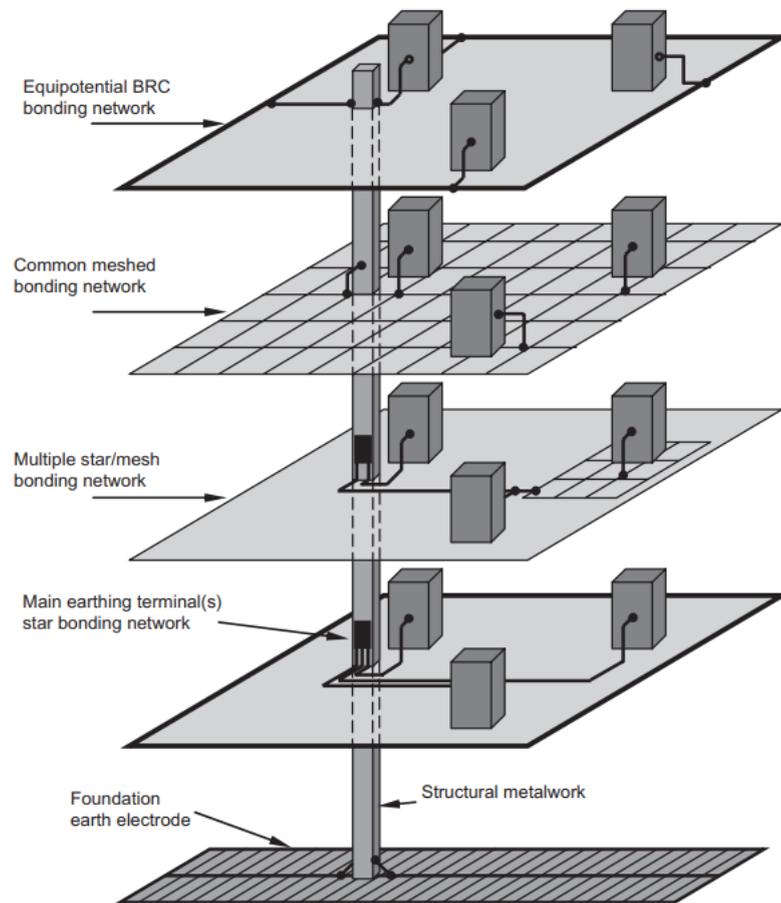
### A444.1.4 Protective conductors connected to a bonding ring conductor

An equipotential bonding network in the form of a bonding ring conductor (BRC) is shown in Figure A444.4 on the top floor of the structure. The BRC should preferably be made of copper, bare or insulated, and installed in such a manner that it remains accessible everywhere, e.g. by mounting on a cable tray, in a metallic conduit (see IEC 61386 series), employing a surface mounted method of installation or cable trunking. All protective and functional earthing conductors may be connected to the BRC.

### A444.2 Equipotential bonding networks in buildings with several floors

For buildings with several floors, it is recommended that, on each floor, an equipotential bonding system be installed; see Figure A444.4 for examples of bonding networks in common use; each floor is a type of network. The bonding systems of the different floors should be interconnected, at least twice, by conductors selected in accordance with the requirements of Chapter 54.

**Fig A444.4 – Example of equipotential bonding networks in a structure without a lightning protection system**



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### **A444.3 Installations containing a high density of interconnected equipment**

In severe electromagnetic environments, it is recommended that the common meshed bonding star network described in A444.1.3 be adopted.

### **A444.4 Design guidelines for segregation of circuits**

Where both the specification of the information technology cable and its intended application is known, the requirements of IEC 60364-5-52 are appropriate.

IEC 60364-5-52 series standards contain requirements and recommendations for the installation of information technology cabling which support a range of applications delivering the following services:

- (i) ICT (information communication technologies) e.g. local area networks
- (ii) BCT (broadcast communication technologies) e.g. audio-visual, television
- (iii) CCCB (command control and communications in buildings) e.g. building automation
- (iv) PMCA (process monitoring, control and automation) e.g. industrial networks (Fieldbus).

Where the specification and/or intended application of the information technology cable is not available, then the cable separation distance between the power and information technology cables should be a minimum of 200 mm in free air.

This distance can be reduced if a screened power cable, a metallic barrier, or containment system is used as described in Table A444.1.

**TABLE A444.1 – Summary of minimum separation distances where the specification and/or the intended application of the information technology cable is not available**

<p>These recommendations of segregation are based upon the following assumptions:</p> <ul style="list-style-type: none"> <li>(i) The electromagnetic environment complies with the levels defined in the IEC 61000-6 series of standards for conducted and radiated disturbances (e.g. mains power cabling)</li> <li>(ii) The LV supply is non-deformed but has high-frequency content consistent with the switching and operation of connected equipment in accordance with the IEC 61000-6 series of standards</li> </ul> <p><b>NOTE:</b> “Deformed” LV power supplies and the use of other equipment lie outside the scope of this standard and might require additional engineering practices.</p> <ul style="list-style-type: none"> <li>(iii) The total design current in the LV circuits does not exceed 600 A</li> <li>(iv) Balanced information technology/telecommunications cables have electromagnetic immunity performance in accordance with KS IEC 60332-1-2 series standards for Category 5 and above</li> <li>(v) Coaxial information technology/telecommunications cables have electromagnetic immunity performance in accordance with IEC 61196-7 standard for Category BCT-C</li> <li>(vi) The applications supported by the cabling are designed to operate using the information technology cabling installed or to be installed.</li> </ul>		
Containment applied to the mains power cabling		
No containment or open metallic containment A <sup>1</sup>	Perforated open metallic containment B <sup>2</sup>	Solid metallic containment C <sup>3</sup>
200 mm	150 mm	Note 4
<p><b>NOTE 1:</b> Screening performance (DC-100MHz) equivalent to welded mesh steel basket of mesh size 50 mm × 100 mm (excluding ladders). This screening performance is also achieved with steel tray (duct without cover) of less than 1.0 mm wall thickness and more than 20% equally distributed perforated area. No part of the cable within the containment should be less than 10 mm below the top of the barrier.</p>		
<p><b>NOTE 2:</b> Screening performance (DC-100 MHz) equivalent to steel tray (duct without cover) of 1.0 mm wall thickness and no more than 20% equally distributed perforated area. This screening performance is also achieved with screened power cables that do not meet the performance defined in Note 1. No part of the cable within the containment should be less than 10 mm below the top of the barrier.</p>		
<p><b>NOTE 3:</b> Screening performance (DC-100 MHz) equivalent to a fully enclosed steel containment system having a minimum wall thickness of 1.5 mm. Separation specified is in addition to that provided by any divider/barrier.</p>		
<p><b>NOTE 4:</b> No physical separation other than that provided by the containment.</p>		

**NOTE:** Zero segregation in the Table references additional segregation/separation for EMC over and above the requirements for safety. Safety considerations must always take precedence over EMC requirements.

Where the above conditions do not apply, see Table A444.2.

**TABLE A444.2 – Minimum separation between power and signal cables (m)**

Power Cable Voltage (V)	Minimum Separation between Power and Signal Cables (m)	Power Cable Current (A)	Minimum Separation between Power and Signal Cables (m)
115	0.25	5	0.24
240	0.45	15	0.35
415	0.58	50	0.5
3300	1.1	100	0.6
6600	1.25	300	0.85
11000	1.4	600	1.05

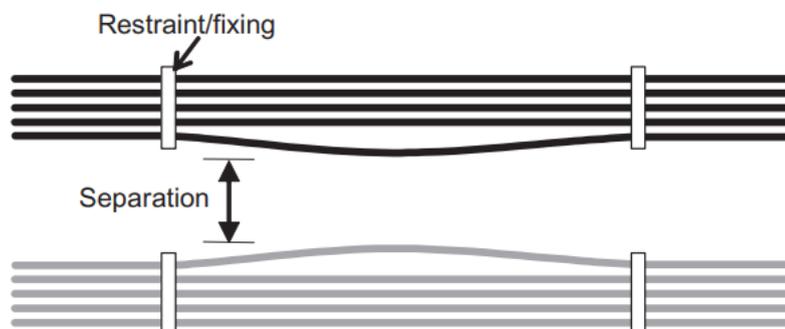
**NOTE 1:** The values in Table A444.2 can be used specifically for long parallel runs of cables.

**NOTE 2:** The worst-case separation based on voltage or current should be used.

Additional areas of concern are expressed in 444.4.1.

The minimum separation between the information technology cables and mains power cables includes all allowances for cable movement between their fixing points or other restraints (see example in Figure A444.5).

**Fig A444.5 – Example of cable separation distance**



The minimum separation requirement applies in three dimensions. However, where information technology cables and mains power cables are required to cross and required minimum separation cannot be maintained then maintaining the angle of their crossing at 90 degrees on either side of the crossing for a distance no less than the applicable minimum separation requirement will minimize any electromagnetic disturbances.

#### **A444.5 Conditions for zero segregation**

See IEC 60364-5-52 series.

### **445 PROTECTION AGAINST UNDERVOLTAGE**

#### **445.1 General requirements**

**445.1.1** Suitable precautions shall be taken where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger. Provisions for a circuit supplying a motor shall comply with 552.1.3.

Where current-using equipment or any other part of the installation may be damaged by a drop in voltage and it is verified that such damage is unlikely to cause danger, one of the following arrangements shall be adopted:

- (i) Suitable precautions against the damage foreseen shall be provided
- (ii) It shall be verified, in consultation with the person or body responsible for the operation and maintenance of the installation, that the damage foreseen is an acceptable risk.

**445.1.2** A suitable time delay may be incorporated in the operation of an undervoltage protective device if the operation of the equipment to which the protection relates allows without danger a brief reduction or loss of voltage.

**445.1.3** Any delay in the opening or reclosing of a contactor shall not impede instantaneous disconnection by a control device or a protective device.

**445.1.4** The characteristics of an undervoltage protective device shall be compatible with the requirements for starting and use of the equipment to which the protection relates, as stated in the appropriate Kenyan Standard.

**445.1.5** Where the reclosure of a protective device is likely to cause danger, the reclosure shall not be automatic.

# CHAPTER 46

## ISOLATION AND SWITCHING

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# CHAPTER 46

## ISOLATION AND SWITCHING

### 460 SCOPE

Chapter 46 deals with:

- (i) non-automatic local and remote isolation and switching measures for the prevention or removal of dangers associated with electrical installations or electrically powered equipment, and
- (ii) switching for the control of circuits or equipment.

Where electrically powered equipment is within the scope of KS IEC 60204, only the requirements of that standard apply.

### 461 GENERAL

**461.1** According to the intended function(s), every device provided for isolation or switching shall comply with the relevant requirements of Chapter 53.

**461.2** In TN-C systems and TN-C-S systems, the PEN conductor shall not be isolated or switched.

In TN-C-S and TN-S systems, isolation or switching of the neutral conductor is not required if protective equipotential bonding is installed and either:

- (i) the neutral conductor is reliably connected to Earth by a low resistance to meet the disconnection times of the protective devices according to the requirements of Chapter 41, or
- (ii) the distributor declares that either the PEN or the neutral conductor of the supply is reliably connected to Earth by a low resistance to meet the disconnection times of the protective devices according to the requirements of Chapter 41.

### 462 ISOLATION

**462.1** Each electrical installation shall have provisions for isolation from each supply.

**462.1.201** A main linked switch or linked circuit-breaker shall be provided as near as practicable to the origin of every installation as a means of switching the supply on load and as a means of isolation.

A main switch intended for operation by ordinary persons, e.g. of a household or similar installation, shall interrupt both live conductors of a single-phase supply.

**462.2** Every circuit shall be provided with isolation means for all live conductors, except as detailed in 461.2.

Provision may be made for isolating a group of circuits by a common means, if the service conditions allow this.

**462.3** Devices for isolation shall be designed and/or installed so as to prevent unintentional or inadvertent closure.

Examples of precautions are as follows:

- Located within a lockable space or lockable enclosure
- Padlocking
- Located adjacent to the associated equipment.

**462.4** Where residual electrical energy is potentially present, suitable means shall be provided for its discharge.

Where relevant, a warning label indicating the discharge time required before the enclosure can be safely opened shall be provided.

**NOTE:** Storage units do not need to be discharged since they are considered to be supply sources.

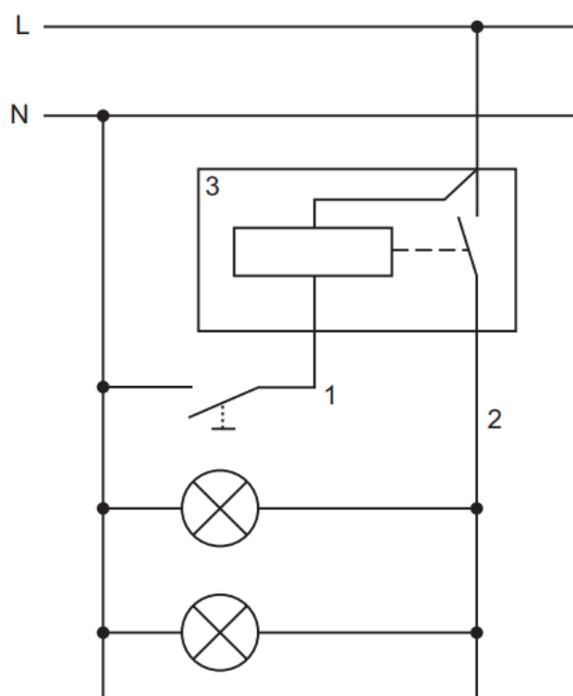
## **463 FUNCTIONAL SWITCHING (CONTROL)**

### **463.1 General**

**463.1.1** Functional switching shall be provided for each part of a circuit which may require to be controlled independently of other parts of the installation.

**463.1.2** Functional switching devices need not necessarily switch off all live conductors of a circuit. A single-pole switching device shall not be placed in the neutral conductor except for the connection of the control device for lighting circuits as shown in Figure 46.1.

**Fig 46.1 – Lamp control circuit with switching in the neutral conductor**



Key

- 1 connection of the control device for lighting circuits
- 2 circuit supplying the lamps
- 3 control device.

Switching of the neutral shall be in compliance with 530.3.3.

**463.1.3** In general, all current-using equipment requiring control shall be controlled by an appropriate functional switching device.

A single functional switching device may control several items of current-using equipment intended to operate simultaneously.

**463.1.4** Functional switching devices ensuring the changeover of supply from alternative sources shall switch off all live conductors and shall not be capable of putting the sources in parallel, unless the installation is specifically designed for this condition.

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## **463.2 Auxiliary circuits**

Auxiliary circuits shall be designed, arranged and protected to limit dangers resulting from a fault in the auxiliary circuit or an insulation fault between the auxiliary circuit and other conductive parts liable to cause malfunction (e.g. inadvertent operation) of the controlled apparatus; see Section 557.

## **463.3 Motor control**

**463.3.1** Motor control circuits shall be designed so as to prevent any motor from restarting automatically after a stoppage due to a fall in or loss of voltage, if such starting is liable to cause danger.

Earth faults in control circuits should not cause unintentional starting, potentially hazardous motion, or prevent stopping of the motor.

**463.3.2** Where reverse-current braking of a motor is provided, provision shall be made for the avoidance of reversal of the direction of rotation at the end of braking if such reversal may cause danger.

**463.3.3** Where safety depends on the direction of rotation of a motor, provision shall be made for the prevention of reverse operation due to a reversal of phases.

**NOTE:** Attention is drawn to danger which may arise from the loss of one phase.

## **464 SWITCHING OFF FOR MECHANICAL MAINTENANCE**

Means for switching off shall be provided where mechanical maintenance may involve a risk of physical injury.

The switching off shall cause the disconnection of all live conductors, except as provided in 461.2, by a device suitable for isolation.

**NOTE 1:** Electrically powered mechanical equipment may include rotating machines as well as heating elements and electromagnetic equipment.

**NOTE 2:** Systems powered by other means, e.g. pneumatic, hydraulic or steam, are not covered by these s. In such cases, switching off any associated supply of electricity may not be a sufficient measure.

**NOTE 3:** Where electrically powered equipment is within the scope of KS IEC 60204, the requirements for switching off for mechanical maintenance of that standard apply.

Suitable means shall be provided to prevent electrically powered equipment from inadvertently or unintentionally reactivating during mechanical maintenance, unless the means of switching off is continuously under the control of any person performing such maintenance.

## **465 EMERGENCY SWITCHING OFF**

Means shall be provided for emergency switching off of any part of an installation where it may be necessary to control the supply to remove an unexpected danger.

Where a risk of electric shock or another risk of electrical origin is involved, the emergency switching off shall cause the disconnection of all live conductors, except as provided in 461.2, by a device suitable for isolation.

Means for emergency switching off shall act as directly as possible on the appropriate supply conductors.

The arrangement for emergency switching off shall be such that one single action only will interrupt the appropriate supply.

The arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger.

**NOTE:** The operation of the switching device is to be understood as switching off in case of emergency and switching on to re-energize the relevant circuit.

The emergency operation function shall not impair the effectiveness of protective devices or of devices with other safety functions.

# ANNEX

## APPENDIX 1 (INFORMATIVE) PROTECTION OF CONDUCTORS IN PARALLEL AGAINST OVERCURRENT INTRODUCTION

Overcurrent protection provided for conductors connected in parallel should provide adequate protection for all of the parallel conductors. For two conductors of the same cross-sectional area, conductor material, length and disposition arranged to carry substantially equal currents the requirements for overcurrent protection are straightforward. For more complex conductor arrangements, detailed consideration should be given to unequal current sharing between conductors and multiple fault current paths. This appendix gives guidance on the necessary considerations.

**NOTE:** A more detailed method for calculating the current between parallel conductors is given in KS IEC 60287.

### Overload protection of conductors in parallel

When an overload occurs in a circuit containing parallel conductors of multicore cables, the current in each conductor will increase by the same proportion. Provided that the current is shared equally between the parallel conductors, a single protective device can be used to protect all the conductors. The current-carrying capacity ( $I_z$ ) of the parallel conductors is the sum of the current-carrying capacity of each conductor, with the appropriate grouping and other factors applied.

The current sharing between parallel cables is a function of the impedance of the cables. For large single-core cables the reactive component of the impedance is greater than the resistive component and will have a significant effect on the current sharing. The reactive component is influenced by the relative physical position of each cable. If, for example, a circuit consists of two large cables per phase, having the same length, construction and cross-sectional area and arranged in parallel with unfavorable relative position (i.e. cables of the same phase bunched together) the current sharing may be more like 70/30 rather than 50/50.

Where the difference in impedance between parallel conductors causes unequal current sharing, for example greater than 10 % difference, the design current and requirements for overload protection for each conductor should be considered individually.

The design current for each conductor can be calculated from the total load and the impedance of each conductor.

For a total of  $m$  conductors in parallel, the design current  $I_{bk}$  for conductor  $k$  is given by:

$$I_{bk} = \frac{I_b}{\left( \frac{Z_k}{Z_1} + \frac{Z_k}{Z_2} + \dots + \frac{Z_k}{Z_{k-1}} + \frac{Z_k}{Z_k} + \frac{Z_k}{Z_{k+1}} + \dots + \frac{Z_k}{Z_m} \right)}$$

where:

- $I_b$  is the current for which the circuit is designed
- $I_{bk}$  is the current design for conductor  $k$
- $Z_k$  is the impedance of conductor  $k$

$Z_1$ ,  $Z_2$  and  $Z_m$  are the impedances of conductors 1, 2 and  $m$  respectively.

For parallel conductors up to and including 120 mm<sup>2</sup> cross-sectional area (csa) the design current  $I_{bk}$  for conductor  $k$  is given by:

$$I_{bk} = I_b \frac{S_k}{S_1 + S_2 + \dots + S_m}$$

where:

- $S_1, \dots, S_m$  is the csa of the conductors and
- $S_k$  is the csa of conductor k.

In the case of single-core cables, the impedance is a function of the relative positions of the cables as well as the design of the cable, for example, armoured or unarmoured. Methods for calculating the impedance are given in KS IEC 60287. It is recommended that current sharing between parallel cables is verified by measurement.

The design current  $I_{bk}$  replaces  $I_b$  in 433.1.1 as follows:

$$I_{bk} \leq I_n \leq I_{zk}$$

The value used for  $I_z$  in 433.1.1 is either:

- (i) the continuous current-carrying capacity of each conductor,  $I_{zk}$ , if an overload protective device is provided for each conductor (see Figure 10A), hence:

$$I_{bk} \leq I_{nk} \leq I_{zk}$$

or

- (ii) the sum of the current-carrying capacities of all the conductors,  $\Sigma I_{zk}$ , if a single overload protective device is provided for the conductors in parallel (see Figure 10B), hence:

$$I_b \leq I_n \leq \Sigma I_{zk}$$

where

- $I_{nk}$  is the rated current of the protective device for conductor k
- $I_{zk}$  is the continuous current-carrying capacity of conductor k
- $I_n$  is the rated current of the protective device
- $\Sigma I_{zk}$  is the sum of the continuous current-carrying capacities of the m conductors in parallel.

**NOTE:** For busbar systems, information should be obtained either from the manufacturer or from KS IEC 61439-6.

For powertrack systems, information should be obtained either from the manufacturer or from IEC 61534.

Fig 10A – Circuit in which an overload protective device is provided for each of the m conductors in parallel

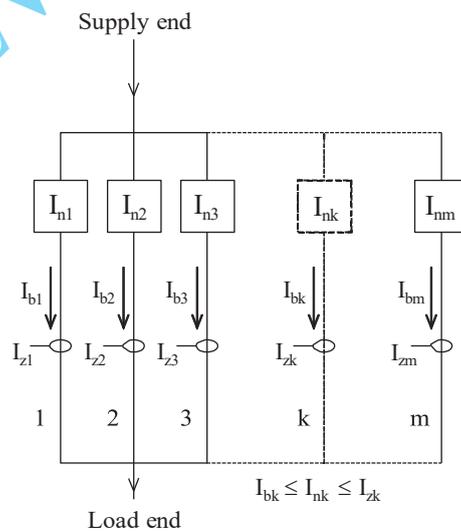
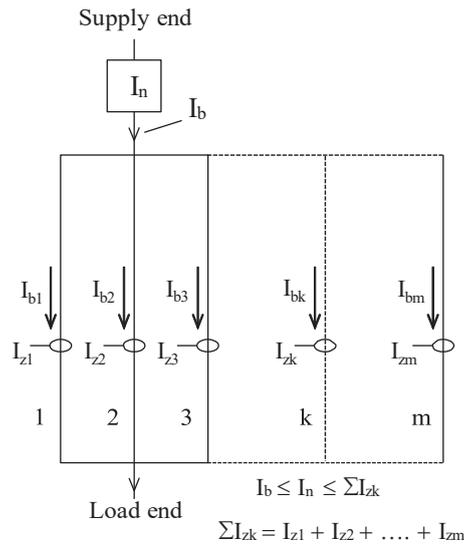


Fig 10B – Circuit in which a single overload protective device is provided for the m conductors in parallel



### Short-circuit protection of conductors in parallel

Where conductors are connected in parallel, the possibility of a short-circuit within the parallel section should be considered.

If two conductors are connected in parallel and the operation of a single protective device may not be effective, then each conductor should have individual protection.

Where three or more conductors are connected in parallel then multiple fault current paths can occur and it may be necessary to provide short-circuit protection at both the supply and load ends of each parallel conductor. This situation is illustrated in Figures 10C and 10D.

Fig 10C – Current flow at the beginning of the fault

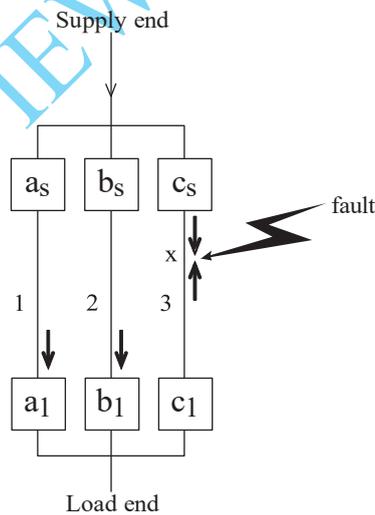


Fig 10D – Current flow after operation of the protective device  $c_s$

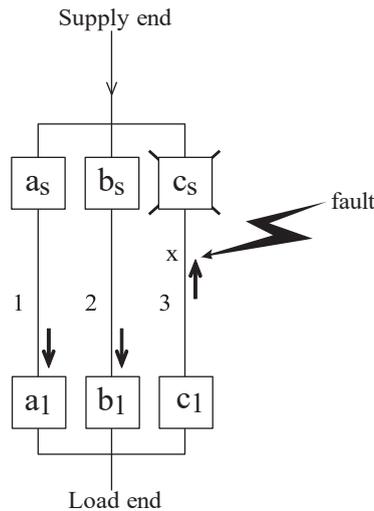
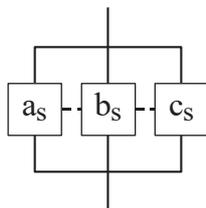


Figure 10C shows that, if a fault occurs in parallel conductor  $c$  at point  $x$ , the fault current will flow in conductors 1, 2 and 3. The magnitude of the fault current and the proportion of the fault current which flows through protective devices  $c_s$  and  $c_l$  will depend on the location of the fault. In this example it has been assumed that the highest proportion of the fault current will flow through protective device  $c_s$ . Figure 10D shows that, once  $c_s$  has operated, current will still flow to the fault at  $x$  via conductors 1 and 2. Because conductors 1 and 2 are in parallel, the current through protective devices  $a_s$  and  $b_s$  may not be sufficient for them to operate in the required time. If this is the case, the protective device  $c_l$  is necessary. It should be noted that the current flowing through  $c_l$  will be less than the current which caused  $c_s$  to operate. If the fault was close enough to  $c_l$  then  $c_l$  would operate first. The same situation would exist if a fault occurred in conductors 1 or 2, hence the protective devices  $a_l$  and  $b_l$  will be required.

The method of providing protective devices at both ends has two disadvantages. Firstly, if a fault at  $x$  is cleared by the operation of  $c_s$  and  $c_l$  then the circuit will continue to operate with the load being carried by conductors 1 and 2. Hence the fault and subsequent overloading of 1 and 2 may not be detected. Secondly, the fault at  $x$  may burn open-circuit at the  $c_l$  side leaving one side of the fault live and undetected.

An alternative method to providing protective devices at both ends would be to provide linked protective devices at the supply end (Figure 10E). This would prevent the continued operation of the circuit under fault conditions.

Fig 10E – Linked protective devices installed at the supply end of the parallel conductors



## APPENDIX 2 (Informative) CLASSIFICATION OF EXTERNAL INFLUENCES

This appendix gives the classification and codification of external influences.

**NOTE 1:** The appendix is an extract from IEC 60364-5-51.

Each condition of external influence is designated by a code comprising a group of two capital letters and a number, as follows:

The first letter relates to the general category of external influence:

- A** Environment
- B** Utilization
- C** Construction of buildings

The second letter relates to the nature of the external influence:

- ... **A**
- ... **B**
- ... **C**

The number relates to the class within each external influence:

- ... .. **1**
- ... .. **2**
- ... .. **3**

For example, the code **AA4** signifies:

- A** = Environment
- AA** = Environment - Ambient temperature
- AA4** = Environment - Ambient temperature in the range of  $-5\text{ °C}$  to  $+40\text{ °C}$ .

**NOTE 2:** The codification given in this appendix is not intended to be used for marking equipment.

The following key is for use when referencing the list of external influences:

- <sup>a</sup> May necessitate certain supplementary precautions (e.g. special lubrication).
- <sup>b</sup> This means that ordinary equipment will operate safely under the described external influences.
- <sup>c</sup> This means that special arrangements should be made, for example, between the designer of the installation and the equipment manufacturer, e.g. for specially designed equipment.

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CONCISE LIST OF EXTERNAL INFLUENCES

	Environment							
	A	AA	Ambient (°C)		AF	Corrosion	AM8	Radiated magnetic fields
		AA1	-60 °C	+5 °C	AF1	Negligible	AM9	Electric fields
		AA2	-40 °C	+5 °C	AF2	Atmospheric	AM21	High-frequency etc. . .
		AA3	-25 °C	+5 °C	AF3	Intermittent	AM22	Conducted. . .nano. . .
		AA4	-5 °C	+40 °C	AF4	Continuous	AM23	Conducted. . .micro. . .
		AA5	+5 °C	+40 °C			AM24	Conducted oscillatory
		AA6	+5 °C	+60 °C	AG	Impact	AM25	Radiated HF
		AA7	-25 °C	+55 °C	AG1	Low	AM31	Electrostatic discharges
		AA8	-50 °C	+40 °C	AG2	Medium	AM41	Ionization
					AG3	High		
		AB	Temperature and Humidity				AN	Solar
					AH	Vibration	AN1	Low
		AC	Altitude (metres)		AH1	Low	AN2	Medium
		AC1	≤ 2000 metres		AH2	Medium	AN3	High
		AC2	> 2000 metres		AH3	High		
		AD	Water		AJ	Other mechanical stresses	AP	Seismic
		AD1	Negligible				AP1	Negligible
		AD2	Drops		AK	Flora	AP2	Low
		AD3	Sprays		AK1	No hazard	AP3	Medium
		AD4	Splashes		AK2	Hazard	AP4	High
		AD5	Jets				AQ	Lightning
		AD6	Waves		AL	Fauna	AQ1	Negligible
		AD7	Immersion		AL1	No hazard	AQ2	Indirect
		AD8	Submersion		AL2	Hazard	AQ3	Direct
		AE	Foreign Bodies		AM	Electromagnetic. . .	AR	Movement of air
		AE1	Negligible		AM1	Level	AR1	Low
		AE2	Small		AM2	Signalling voltages	AR2	Medium
		AE3	Very small		AM3	Voltage amplitude variations	AR3	High
		AE4	Light dust		AM4	Voltage unbalance		
		AE5	Moderate dust		AM5	Power frequency variations	AS	Wind
		AE6	Heavy dust		AM6	Induced low-frequency voltage	AS1	Low
					AM7	DC current in AC voltage	AS2	Medium
							AS3	High
	Utilization							
	B	BA	Capability		BC	Contact with Earth	BE	Materials
		BA1	Ordinary		BC1	None	BE1	No risk
		BA2	Children		BC2	Low	BE2	Fire risk
		BA3	Handicapped		BC3	Frequent	BE3	Explosion risk
		BA4	Instructed		BC4	Continuous	BE4	Contamination risk
		BA5	Skilled					
		BB	Resistance		BD	Evacuation		
					BD1	Normal		
					BD2	Difficult		
					BD3	Crowded		
					BD4	Difficult and crowded		
	Buildings							
	C	CA	Materials		CB	Structure		
		CA1	Non-combustible		CB1	Negligible		
		CA2	Combustible		CB2	Fire propagation		
					CB3	Structural movement		
					CB4	Flexible		

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A ENVIRONMENT:

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only	
A	<i>Environmental conditions</i>			
AA	<i>Ambient temperature</i>			
	<p>The ambient temperature is that of the ambient air where the equipment is to be installed</p> <p>It is assumed that the ambient temperature includes the effects of other equipment installed in the same location</p> <p>The ambient temperature to be considered for the equipment is the temperature at the place where the equipment is to be installed resulting from the influence of all other equipment in the same location, when operating, not taking into account the thermal contribution of the equipment to be installed.</p>			
AA1	-60 °C +5 °C	Specially designed equipment or appropriate arrangements <sup>a</sup>	Includes temperature range of IEC 60721-3-3, class 3K8, with high air temperature restricted to +5 °C. Part of temperature range of IEC 60721-3-4, class 4K4, with low air temperature restricted to -60 °C and high air temperature restricted to +5 °C	
AA2	-40 °C +5 °C		Part of temperature range of IEC 60721-3-3, class 3K7, with high air temperature restricted to +5 °C. Includes part of temperature range of IEC 60721-3-4, class 4K3, with high air temperature restricted to +5 °C	
AA3	-25 °C +5 °C		Part of temperature range of IEC 60721-3-3, class 3K6, with high air temperature restricted to +5 °C. Includes temperature range of IEC 60721-3-4, class 4K1, with high air temperature restricted to +5 °C	
AA4	-5 °C +40 °C		Normal (in certain cases special precautions may be necessary)	Part of temperature range of IEC 60721-3-3, class 3K5, with high air temperature restricted to +40 °C
AA5	+5 °C +40 °C		Normal <sup>b</sup>	Identical to temperature range of IEC 60721-3-3, class 3K3

**A ENVIRONMENT (cont.)**

Code	External influences						Characteristics required for selection and erection of equipment	Reference for information only
AA6	+5 °C +60 °C						Specially designed equipment or appropriate arrangements <sup>a</sup>	Part of temperature range of IEC 60721-3-3, class 3K7, with low air temperature restricted to +5 °C and high air temperature restricted to +60 °C. Includes temperature range of IEC 60721-3-4, class 4K4 with low air temperature restricted to +5 °C
AA7	-25 °C +55 °C } -50 °C +40 °C }							
AA8	<p>Ambient temperature classes are applicable only where humidity has no influence</p> <p>The average temperature over a 24 h period must not exceed 5 °C below the upper limits</p> <p>Combination of two ranges to define some environments may be necessary. Installations subject to temperatures outside the ranges require special consideration</p>							
AB	<i>Atmospheric humidity</i>							
	<b>Air temperature °C</b> a) low b) high		<b>Relative humidity %</b> c) low d) high		<b>Absolute humidity g/m<sup>3</sup></b> e) low f) high			
AB1	-60	+5	3	100	0.003	7	Indoor and outdoor locations with extremely low ambient temperatures	Includes temperature range of IEC 60721-3-3, class 3K8, with high air temperature restricted to +5°C. Part of temperature range of IEC 60721-3-4, class 4K4, with low air temperature restricted to – 60°C and high air temperature restricted to +5°C
	Appropriate arrangements should be made <sup>e</sup>							
AB2	-40	+5	10	100	0.1	7	Indoor and outdoor locations with low ambient temperatures	Part of temperature range of IEC 60721-3-3, class 3K7, with high temperature restricted to +5°C. Part of temperature range of IEC 60721-3-4, class 4K4, with low air temperature restricted to – 40°C and high air temperature restricted to +5°C
	Appropriate arrangements should be made <sup>e</sup>							

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**A ENVIRONMENT (cont.)**

Code	External influences						Characteristics required for selection and erection of equipment	Reference for information only
	Air temperature °C a) low b) high		Relative humidity % c) low d) high		Absolute humidity g/m <sup>3</sup> e) low f) high			
AB3	-25	+5	10	100	0.5	7	Indoor and outdoor locations with low ambient temperatures  Appropriate arrangements should be made <sup>c</sup>	Part of temperature range of IEC 60721-3-3, class 3K6, with high air temperature restricted to +5°C. Includes temperature range of IEC 60721-3-4, class 4K1, with high air temperature range restricted to +5°C
AB4	-5	+40	5	95	1	29	Weather protected locations having neither temperature nor humidity control. Heating may be used to raise low ambient temperatures  Normal <sup>b</sup>	Identical with temperature range of IEC 60721-3-3, class 3K5. The high air temperature restricted to +40°C
AB5	+5	+40	5	85	1	25	Weather protected locations with temperature control  Normal <sup>b</sup>	Identical with temperature range of IEC 60721-3-3, class 3K3
AB6	+5	+60	10	100	1	35	Indoor and outdoor locations with extremely high ambient temperatures, influence of cold ambient temperatures is prevented. Occurrence of solar and heat radiation  Appropriate arrangements should be made <sup>c</sup>	Part of temperature range of IEC 60721-3-3, class 3K7, with low air temperature restricted to +5°C and high air temperature restricted to +60°C. Includes temperature range of IEC 60721-3-4, class 4K4, with low air temperature restricted to +5°C
AB7	-25	+55	10	100	0.5	29	Indoor weather protected locations having neither temperature nor humidity control, the locations may have openings directly to the open air and be subjected to solar radiation  Appropriate arrangements must be made <sup>c</sup>	Identical to temperature range of IEC 60721-3-3, class 3K6
AB8	-50	+40	15	100	0.04	36	Outdoor and non-weather protected locations, with low and high temperatures  Appropriate arrangements should be made <sup>c</sup>	Identical to temperature range of IEC 60721-3-4, class 4K3

**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AC AC1 AC2	<i>Altitude</i> ≤2 000 m >2 000 m	Normal <sup>b</sup> May necessitate special precautions such as the application of derating factors <b>NOTE:</b> For some equipment special arrangements may be necessary at altitudes of 1 000 m and above	
AD AD1  AD2  AD3  AD4  AD5  AD6  AD7  AD8	<i>Presence of water</i> Negligible  Free-falling drops  Sprays  Splashes  Jets  Waves  Immersion  Submersion	IPX0 Probability of presence of water is negligible. Location in which the walls do not generally show traces of water but may do so for short periods, for example in the form of vapour which good ventilation dries rapidly IPX1 or IPX2 Possibility of vertically falling drops Location in which water vapour occasionally condenses as drops or where steam may occasionally be present IPX3 Possibility of water falling as a spray at an angle up to 60° from the vertical Locations in which sprayed water forms a continuous film on floors and/or walls IPX4 Possibility of splashes from any direction Locations where equipment may be subjected to splashed water; this applies, for example, to certain external luminaires, construction site equipment IPX5 Possibility of jets of water from any direction Locations where hose water is used regularly (yards, car-washing bays) IPX6 Possibility of water waves Seashore locations such as piers, beaches, quays, etc IPX7 Locations which may be flooded and/or where the equipment is immersed as follows: <ul style="list-style-type: none"> <li>• Equipment with a height of less than 850 mm is located in such a way that its lowest point is not more than 1 000 mm below the surface of the water</li> <li>• Equipment with a height equal to or greater than 850 mm is located in such a way that its highest point is not more than 150 mm below the surface of the water</li> </ul> IPX8 Possibility of permanent and total covering by water Locations such as swimming pools where electrical equipment is permanently and totally covered with water	IEC 60529 IEC 60721-3-4, class 4Z6  IEC 60529 IEC 60721-3-3, class 3Z7  IEC 60529 IEC 60721-3-3, class 3Z8 IEC 60721-3-4, class 4Z7 IEC 60529 IEC 60721-3-3, class 3Z9 IEC 60721-3-4, class 4Z7  IEC 60529 IEC 60721-3-3, class 3Z10 IEC 60721-3-4, class 4Z8 IEC 60529 IEC 60721-3-4, class 4Z9

**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AE	<i>Presence of foreign solid bodies</i>	IPXX see also Section 416	
AE1	Negligible	IP0X The quantity or size of dust or foreign solid bodies is not significant	IEC 60529 IEC 60721-3-3, class 3S1 IEC 60721-3-4, class 4S1
AE2	Small objects (2.5 mm)	IP3X Presence of foreign solid bodies where the smallest dimension is not less than 2.5 mm Tools and small objects are examples of foreign solid bodies of which the smallest dimension is at least 2.5 mm	IEC 60529 IEC 60721-3-3, class 3S2 IEC 60721-3-4, class 4S2
AE3	Very small objects (1 mm)	IP4X Presence of foreign solid bodies where the smallest dimension is not less than 1 mm Wires are examples of foreign solid bodies of which the smallest dimension is not less than 1 mm	IEC 60529 IEC 60721-3-3, class 3S3 IEC 60721-3-4, class 4S3
AE4	Light dust	IP5X Presence of dust if dust penetration is not harmful to the functioning of the equipment	IEC 60529 IEC 60721-3-3, class 3S2 IEC 60721-3-4, class 4S2 IEC 60529
AE5	Moderate dust	IP6X Presence of dust if dust penetration is harmful to the functioning of the equipment	IEC 60721-3-4, class 3S3 IEC 60721-3-3, class 4S3 IEC 60721-3-3, class 3S4
AE6	Heavy dust	IP6X Presence of dust Dust must not penetrate equipment	IEC 60721-3-4, class 4S4
AF	<i>Presence of corrosive or polluting substances</i>		
AF1	Negligible	Normal <sup>b</sup>	IEC 60721-3-3, class 3C1 IEC 60721-3-4, class 4C1
AF2	Atmospheric	The presence of corrosive or polluting substances of atmospheric origin is significant. Installations situated by the sea or near industrial zones producing serious atmospheric pollution, such as chemical works, cement works; this type of pollution arises especially in the production of abrasive, insulating or conductive dusts  According to the nature of substances (for example, satisfaction of salt mist test according to IEC 60068-2-11)	IEC 60721-3-3, class 3C2 IEC 60721-3-4, class 4C2
AF3	Intermittent or accidental	Intermittent or accidental subjection to corrosive or polluting chemical substances being used or produced Locations where some chemical products are handled in small quantities and where these products may come only accidentally into contact with electrical equipment; such conditions are found in factory laboratories, other laboratories or in locations where hydrocarbons are used (boiler-rooms, garages, etc.)  Protection against corrosion according to equipment specification	IEC 60721-3-3, class 3C3 IEC 60721-3-4, class 4C3

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AF4	Continuous	Continuously subject to corrosive or polluting chemical substances in substantial quantity, e.g. chemical works Equipment specially designed according to the nature of substances	IEC 60721-3-3, class 3C4 IEC 60721-3-4, class 4C4
AG	<i>Mechanical stress: Impact</i>		
AG1	Low severity	Normal, e.g. household and similar equipment	IEC 60721-3-3, classes 3M1/3M2/3M3 IEC 60721-3-4, classes 4M1/4M2/4M3
AG2	Medium severity	Standard industrial equipment, where applicable, or reinforced protection	IEC 60721-3-3, classes 3M4/3M5/3M6 IEC 60721-3-4, classes 4M4/4M5/4M6
AG3	High severity	Reinforced protection	IEC 60721-3-3, classes 3M7/3M8 IEC 60721-3-4, classes 4M7/4M8

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**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AH AH1	<i>Vibration</i> Low severity	Household and similar conditions where the effects of vibration are generally negligible  Normal	IEC 60721-3-3, classes 3M1/3M/3M3  IEC 60721-3-4, classes 4M1/4M2/4M3
AH2	Medium severity	Usual industrial conditions Specially designed equipment or special arrangements	IEC 60721-3-3, classes 3M4/3M5/3M6  IEC 60721-3-4, classes 4M4/4M5/4M6
AH3	High severity	Industrial installations subject to severe conditions Specially designed equipment or special arrangements	IEC 60721-3-3, classes 3M7/3M8  IEC 60721-3-4, classes 4M7/4M8
AJ	<i>Other mechanical stresses</i>	Under consideration	
AK AK1	<i>Presence of flora and/or mould growth</i> No hazard	No harmful hazard from flora and/or mould growth  Normal <sup>b</sup>	IEC 60721-3-3, class 3B1  IEC 60721-3-4, class 4B1
AK2	Hazard	Harmful hazard from flora and/or mould growth  The hazard depends on local conditions and the nature of flora. Distinction should be made between harmful growth of vegetation or conditions for promotion of mould growth  Special protection, such as: <ul style="list-style-type: none"> <li>– increased degree of protection (see AE)</li> <li>– special materials or protective coating of enclosures</li> <li>– arrangements to exclude flora from location</li> </ul>	IEC 60721-3-3, class 3B2 IEC 60721-3-4, class 4B2
AL AL1	<i>Presence of fauna</i> No hazard	No harmful hazard from fauna  Normal <sup>b</sup>	IEC 60721-3-3, class 3B1 IEC 60721-3-4, class 4B1

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Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AL2	Hazard	<p>Harmful hazard from fauna (insects, birds, small animals) The hazard depends on the nature of the fauna. Distinction should be made between:</p> <ul style="list-style-type: none"> <li>– presence of insects in harmful quantity or of an aggressive nature;</li> <li>– presence of small animals or birds in harmful quantity or of an aggressive nature</li> </ul> <p>Protection may include:</p> <ul style="list-style-type: none"> <li>– an appropriate degree of protection against penetration of foreign solid bodies (see AE)</li> <li>– sufficient mechanical resistance (see AG)</li> <li>– precautions to exclude fauna from the location (such as cleanliness, use of pesticides)</li> <li>– special equipment or protective coating of enclosures</li> </ul>	IEC 60721-3-3, class 3B2 IEC 60721-3-4, class 4B2

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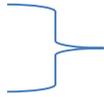
**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AM	<i>Electromagnetic, electrostatic, or ionizing influences</i>  <i>Low-frequency electromagnetic phenomena (conducted or radiated)</i>  <i>Harmonics, interharmonics</i>		
AM-1-1	Controlled level	Care should be taken that the controlled situation is not impaired	Lower than table 1 of IEC 61000-2-2
AM-1-2	Normal level	Special measures in the design of the installation, e.g. filters	Complying with table 1 of IEC 61000-2-2
AM-1-3	High level	Special measures in the design of the installation, e.g. filters	Locally higher than table 1 of IEC 61000-2-2
AM-2-1	<i>Signalling voltages</i> Controlled level	Possibly: blocking circuits	Lower than specified below IEC/TR 61000-2-1 and IEC 61000-2-2
AM-2-2	Medium level	No additional requirement	
AM-2-3	High level	Appropriate measures	
AM-3-1	<i>Voltage amplitude variations</i> Controlled level	e.g. controlled by UPS	
AM-3-2	Normal level	Compliance with KS 662-4 Chapter 44	
AM-4	<i>Voltage unbalance</i>		Compliance with IEC 61000-2-2
AM-5	<i>Power frequency variations</i>		±1 Hz according to IEC 61000-2-2
AM-6	<i>Induced low-frequency voltages</i> No classification	Refer to KS 662-4 Chapter 44  High withstand of signal and control systems of switchgear and controlgear	ITU-T (International Telecommunication Union)
AM-7	<i>Direct current in AC networks (321.10.1.7)</i> No classification	Measures to limit their presence in level and time in the current-using equipment or their vicinity	
AM-8-1	<i>Radiated magnetic fields</i> Medium level	Normal <sup>b</sup>	Level 2 of IEC 61000-4-8
AM-8-2	High level	Protection by appropriate measures e.g. screening and/or separation	Level 4 of IEC 61000-4-8

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**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AM-9-1 AM-9-2 AM-9-3 AM-9-4	<i>Electric fields</i> Negligible level Medium level High level Very high level	Normal <sup>b</sup>	IEC TR 61000-2-5 IEC TR 61000-2-5 IEC TR 61000-2-5
<i>High-frequency electromagnetic phenomena conducted, induced or radiated (continuous or transient)</i>			
AM-21	<i>Induced oscillatory voltages or currents</i> No classification	Normal <sup>b</sup>	IEC 61000-4-6
AM-22-1 AM-22-2 AM-22-3 AM-22-4	<i>Conducted unidirectional transients of the nanosecond time scale</i> Negligible level Medium level High level Very high level	Protective measures are necessary Protective measures are necessary Normal equipment High immunity equipment	IEC 61000-4-4 Level 1 Level 2 Level 3 Level 4
AM-23-1 AM-23-2 AM-23-3	<i>Conducted unidirectional transients of microsecond to millisecond time scale</i> Controlled level Medium level High level	Impulse withstand of equipment and overvoltage protective means chosen taking into account the nominal supply voltage and the impulse withstand category according to KS 662-4 Chapter 44	KS 662-4 Chapter 44 KS 662-4 Chapter 44
AM-24-1 AM-24-2	<i>Conducted oscillatory transients</i> Medium level High level	Refer to IEC 61000-4-12 Refer to IEC 60255-26	IEC 61000-4-12 IEC 60255-26:2013
AM-25-1 AM-25-2 AM-25-3	<i>Radiated high-frequency phenomena</i> Negligible level Medium level High level	Normal <sup>b</sup> Reinforced level	IEC 61000-4-3 Level 1 Level 2 Level 3
AM-31-1 AM-31-2 AM-31-3 AM-31-4	<i>Electrostatic discharges</i> Small level Medium level High level Very high level	Normal <sup>b</sup> Normal <sup>b</sup> Normal <sup>b</sup> Reinforced	IEC 61000-4-2 Level 1 Level 2 Level 3 Level 4
AM-41-1	<i>Ionization</i> No classification	Special protection such as: – Spacings from source – Interposition of screens, enclosure by special materials	



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**A ENVIRONMENT (cont.)**

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
AN AN1 AN2 AN3	<i>Solar radiation</i> Low Medium High	Intensity $\leq 500 \text{ W/m}^2$ Normal <sup>b</sup> 500 $\text{W/m}^2 < \text{intensity} \leq 700 \text{ W/m}^2$ Appropriate arrangements must be made <sup>c</sup> 700 $\text{W/m}^2 < \text{intensity} \leq 1120 \text{ W/m}^2$ Appropriate arrangements must be made <sup>c</sup> Such arrangements could be: – material resistant to ultraviolet radiation – special colour coating – interposition of screens	IEC 60721-3-3 class 3K1 IEC 60721-3-3 Classes 3K2 to 3K5 IEC 60721-3-3 Higher than class 3K5 IEC 60721-3-4
AP AP1 AP2 AP3 AP4	<i>Seismic effects</i> Negligible Low severity Medium severity High severity	Acceleration $\leq 30 \text{ Gal}$ (1 Gal = 1cm/s <sup>2</sup> ) Normal <sup>b</sup> 30 Gal < acceleration $\leq 300 \text{ Gal}$ Under consideration 300 Gal < acceleration $\leq 600 \text{ Gal}$ Under consideration 600 Gal < acceleration Under consideration Vibration which may cause the destruction of the building is outside the classification Frequency is not taken into account in the classification; however, if the seismic wave resonates with the building, seismic effects must be specially considered. In general, the frequency of seismic acceleration is between 0 Hz and 10 Hz	
AQ AQ1 AQ2 AQ3	<i>Lightning</i> Negligible Indirect exposure Direct exposure	Normal <sup>b</sup> In accordance with Section 443 IEC 62305-1	
AR AR1 AR2 AR3	<i>Movement of air</i> Low Medium High	Speed $\leq 1 \text{ m/s}$ Normal <sup>b</sup> 1 m/s < speed $\leq 5 \text{ m/s}$ Appropriate arrangements should be made <sup>c</sup> 5 m/s < speed $\leq 10 \text{ m/s}$ Appropriate arrangements should be made <sup>c</sup>	
AS AS1 AS2 AS3	<i>Wind</i> Low Medium High	Speed $\leq 20 \text{ m/s}$ Normal <sup>b</sup> 20 m/s < speed $\leq 30 \text{ m/s}$ Appropriate arrangements should be made <sup>c</sup> 30 m/s < speed $\leq 50 \text{ m/s}$ Appropriate arrangements should be made <sup>c</sup>	

## B UTILIZATION:

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only												
BA	<b>Capability of persons</b>														
BA1	Ordinary	Uninstructed persons Normal <sup>b</sup>	Inaccessibility of electrical equipment. Limitation of temperature of accessible surfaces												
BA2	Children	Locations intended for presence of children e.g. nurseries, infant schools, etc. Equipment of degrees of protection equal to or greater than IP2XC. Inaccessibility of equipment with external surface temperature exceeding 60 °C													
BA3	Handicapped	Persons not in command of all their physical and/or intellectual abilities (sick persons, old persons) According to the nature of the handicap													
BA4	Instructed														
BA5	Skilled	Persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff) Electrical operating areas  Equipment not having basic protection against direct contact with live parts admitted solely in locations which are accessible only to duly authorized persons with technical knowledge or sufficient experience to enable them to avoid danger which electricity may create (engineers and technicians) Closed electrical operating areas													
BB	<b>Electrical resistance of the human body</b> Under consideration														
BC	<b>Contact of persons with Earth potential</b>														
BC1	None	<p><b>Class of equipment according to KS IEC 61140</b></p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <td>Persons in non-conducting situations</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>A</td> <td>A</td> <td>A</td> </tr> </table>		I	II	III	Persons in non-conducting situations					A	A	A	
	I	II	III												
Persons in non-conducting situations															
	A	A	A												
BC2	Occasional	Persons who do not in usual conditions make contact with extraneous-conductive-parts or stand on conducting surfaces													
BC3	Frequent	Persons who are frequently in touch with extraneous-conductive-parts or stands on conducting services Locations with extraneous-conductive-parts, either numerous or of a large area													
		<p>Class of equipment according to KS IEC61140</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td>0-01</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <td>X</td> <td>A</td> <td>A</td> <td>A</td> </tr> </table> <p>A Equipment permitted X Equipment prohibited Y Permitted if used as class 0</p>	0-01	I	II	III	X	A	A	A					
0-01	I	II	III												
X	A	A	A												
BC4	Continuous	Persons who are immersed in water or in long term permanent contact with metallic surroundings and for whom the possibility of interrupting contact is limited Metallic surroundings such as boilers and tanks	Under consideration												
BD	<b>Conditions of evacuation in an emergency</b>														
BD1	Low density / easy exit	Normal <sup>b</sup>  Low density occupation, easy conditions of evacuation  Buildings of normal or low height used for habitation													
BD2	Low density / difficult exit	Low density occupation, difficult conditions of evacuation  High-rise buildings													
BD3	High density / easy exit	High density occupation, easy conditions of evacuation  Locations open to the public (theatres, cinemas, departments stores, etc.)													
BD4	High density / difficult exit	High density occupation, difficult conditions of evacuation  High-rise buildings open to the public (hotels, hospitals, etc.)													

Code	External influences	Characteristics required for selection and erection of equipment	Reference for information only
BE	<b>Nature of processed or stored materials</b>		
BE1	No significant risk	Normal <sup>b</sup>	
BE2	Fire risks	<p>Manufacture, processing or storage of flammable materials including presence of dust</p> <p>Barns, wood-working shops, paper factories</p> <p>Equipment made of material retarding the spread of flame</p> <p>Arrangements such that a significant temperature rise or a spark within electrical equipment cannot initiate an external fire</p>	<p>Chapter 42</p> <p>Chapter 52</p>
BE3	Explosion risks	<p>Processing or storage of explosive or low-flash-point materials including presence of explosive dusts</p> <p>Oil refineries, hydrocarbon stores</p> <p>Requirements for electrical apparatus for explosive atmospheres (see KS IEC 60079),</p>	Under consideration
BE4	Contamination risks	<p>Presence of unprotected foodstuffs, pharmaceuticals, and similar products without protection</p> <p>Foodstuff industries, kitchens:</p> <p>Certain precautions may be necessary, in the event of fault, to prevent processed materials being contaminated by electrical equipment, e.g. by broken lamps</p> <p>Appropriate arrangements, such as:</p> <ul style="list-style-type: none"> <li>protection against falling debris from broken lamps and other fragile objects</li> <li>screens against harmful radiation such as infrared or ultraviolet</li> </ul>	Under consideration

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**C CONSTRUCTION OF BUILDINGS:**

<b>Code</b>	<b>External influences</b>	<b>Characteristics required for selection and erection of equipment</b>	<b>Reference for information only</b>
CA	<b>Construction materials</b>		
CA1	Non-combustible	Normal	
CA2	Combustible	Buildings mainly constructed of combustible materials Wooden buildings Under consideration	IEC 60364-4-42
CB	<b>Building design</b>		
CB1	Negligible risks	Normal	
CB2	Propagation of fire	Buildings of which the shape and dimensions facilitate the spread of fire (e.g. chimney effect) High-rise buildings. Forced ventilation systems  Equipment made of material retarding the propagation of fire including fires not originating from the electrical installation.  Fire barriers	IEC 60364-4-42 IEC 60364-5-52
CB3	Movement	Risk due to structural movement (e.g. displacement)  Buildings of considerable length or erected on unstable ground	Contraction or expansion joints (under consideration) IEC 60364-5-52
CB4	Flexible or unstable	Contraction or expansion joints in electrical wiring  Structures which are weak or subject to movement (e.g. oscillation)  Tents, air-support structures, false ceilings, removable partitions. Installations to be structurally self-supporting  Under consideration	Flexible wiring IEC 60364-5-52

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