

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage switchgear and controlgear assemblies –
Part 1: General rules**

**Ensembles d'appareillage à basse tension –
Partie 1: Règles générales**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –**Part 1: General rules****FOREWORD**

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International Standard IEC 61439-1 has been prepared by subcommittee 121B: Low-voltage switchgear and controlgear assemblies, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This third edition cancels and replaces the second edition published in 2011. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) clarification that power electric converter systems, switch mode power supplies, uninterruptable power supplies and adjustable speed power drive systems are tested to their particular products standard, but when they are incorporated in assemblies the incorporation is in accordance with the IEC 61439 series of standards;
- b) introduction of a group rated current for circuits within a loaded assembly and the refocusing of temperature-rise verification on this new characteristic;

- c) addition of requirements in respect of DC;
- d) introduction of the concept of class I and class II assemblies regarding protection against electric shock.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
121B/99/FDIS	121B/103/RVD

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

The reader's attention is drawn to the fact that Annex N lists all the "in-some-countries" clauses on differing practices of a less permanent nature regarding this document.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61439 series, under the general title *Low-voltage switchgear and controlgear assemblies*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

INTRODUCTION

The purpose of this document is to harmonize as far as practicable all rules and requirements of a general nature applicable to low-voltage switchgear and controlgear assemblies, in order to obtain uniformity of requirements and verification for assemblies and to avoid the need for verification in other standards. All those requirements for the various assembly standards which can be considered as general have therefore been gathered in this document together with specific subjects of wide interest and application, e.g. temperature-rise, dielectric properties, etc.

For each type of low-voltage switchgear and controlgear assembly, only two main standards are necessary to determine all requirements and the corresponding methods of verification:

- the basic standard, (this document) referred to as “IEC 61439-1” in the specific standards, covering the various types of low-voltage switchgear and controlgear assemblies;
- the specific assembly standard hereinafter also referred to as the relevant assembly standard.

For a general rule to apply to a specific assembly standard, it should be explicitly referred to by quoting this document followed by the relevant clause or subclause number e.g. “IEC 61439-1:2020, 9.1.3”.

A specific assembly standard may not require, and hence need not call up, a general rule where it is not applicable, or it can add requirements if the general rule is deemed inadequate in the particular case, but it may not deviate from it unless there is substantial technical justification detailed in the specific assembly standard.

Where, in this document, a cross-reference is made to another clause, the reference is to be taken to apply to that clause as amended by the specific assembly standard, where applicable.

Requirements in this document that are subject to agreement between the assembly manufacturer and the user are summarized in Annex C (informative). This schedule also facilitates the supply of information on basic conditions and additional user specifications to enable proper design, application and utilization of the assembly.

For the IEC 61439 series, the following parts are published:

- a) IEC 61439-1: General rules
- b) IEC 61439-2: Power switchgear and controlgear assemblies (PSC-assemblies)¹
- c) IEC 61439-3: Distribution boards intended to be operated by ordinary persons (DBO)
- d) IEC 61439-4: Particular requirements for assemblies for construction sites (ACS)
- e) IEC 61439-5: Assemblies for power distribution in public networks
- f) IEC 61439-6: Busbar trunking systems (busways)
- g) IEC 61439-7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations
- h) IEC TR 61439-0: Guidance to specifying assemblies.

This list is not exhaustive; additional parts can be developed as the need arises.

¹ IEC 61439-2 includes requirements for assemblies for use in photovoltaic installations.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –

Part 1: General rules

1 Scope

This part of IEC 61439 lays down the general definitions and service conditions, construction requirements, technical characteristics and verification requirements for low-voltage switchgear and controlgear assemblies.

NOTE Throughout this document, the term assembly(s) (see 3.1.1) is used for a low-voltage switchgear and controlgear assembly(s).

For the purpose of determining assembly conformity, the requirements of the relevant part of the IEC 61439 series, Part 2 onwards, apply together with the cited requirements of this document. For assemblies not covered by Part 3 onward, Part 2 applies.

This document applies to assemblies only when required by the relevant assembly standard as follows:

- assemblies for which the rated voltage does not exceed 1 000 V AC or 1 500 V DC;
- assemblies designed for a nominal frequency of the incoming supply or supplies not exceeding 1 000 Hz;
- assemblies intended for indoor and outdoor applications;
- stationary or movable assemblies with or without an enclosure;
- assemblies intended for use in connection with the generation, transmission, distribution and conversion of electric energy, and for the control of electrical energy consuming equipment.

This document does not apply to individual devices and self-contained components such as motor starters, fuse switches, power electronic converter systems and equipment (PECS), switch mode power supplies (SMPS), uninterruptable power supplies (UPS), basic drive modules (BDM), complete drive modules (CDM), adjustable speed power drives systems (PDS), and other electronic equipment which comply with their relevant product standards. This document describes the integration of devices and self-contained components into an assembly or into an empty enclosure forming an assembly.

For some applications involving, for example, explosive atmospheres, functional safety, there can be a need to comply with the requirements of other standards or legislation in addition to those specified in the IEC 61439 series.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-11:1981, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60073:2002, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

IEC 60364-5-52:2009, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

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² Withdrawn. The IEC 60439 series has been cancelled and replaced by the IEC 61439 series.

³ There is a consolidated document edition 2.2 (2013) that includes IEC 60529 (1989) and its Amendment 1 (1999) and Amendment 2 (2013).

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio frequency, electromagnetic field immunity test*⁴

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IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*⁵

IEC 61000-4-5:2014/AMD1:2017

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⁴ There is a consolidated edition 3.2 (2010) that includes IEC 61000-4-3 (2006) and Amendment 1 (2007) and Amendment 2 (2010).

⁵ There is consolidated edition 3.1 (2017) that includes IEC 61000-4-5 (2014) and its Amendment 1 (2017).

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ISO 2409:2013, *Paints and varnishes – Cross-cut test*

ISO 4628-3:2016, *Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 3: Assessment of degree of rusting*

ISO 4892-2:2013, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General terms

3.1.1

low-voltage switchgear and controlgear assembly

combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, with all the internal electrical and mechanical interconnections and structural parts, as defined by the original manufacturer, which can be assembled in accordance with the original manufacturer's instructions

Note 1 to entry: Throughout this document, the term assembly(s) is used for a low-voltage switchgear and controlgear assembly(s)

Note 2 to entry: The term "switching device" includes mechanical switching devices and semiconductor switching devices, e.g. soft starters, semiconductor relays, frequency converters. The auxiliary circuits may also include electro-mechanical devices, e.g. control relays, terminal blocks, and electronic devices, e.g. electronic motor control devices, electronic measurement and protection devices, bus communication, programmable logic controller systems.

3.1.2**assembly system**

full range of mechanical and electrical components (enclosures, busbars, functional units, auxiliary circuits and associated controls, etc.), as defined by the original manufacturer, which can be assembled in accordance with the original manufacturer's instructions in order to produce various assemblies

3.1.3**main circuit**

all the conductive parts of an assembly included in a circuit which is intended to transmit electrical energy

[SOURCE: IEC 60050-441:2000, 441-13-02]

3.1.4**auxiliary circuit**

all the conductive parts of an assembly included in a circuit (other than the main circuit) intended to control, measure, signal, regulate and process data, etc.

Note 1 to entry: The auxiliary circuits of an assembly include the control and the auxiliary circuits of the switching devices.

[SOURCE: IEC 60050-441:2000, 441-13-03, modified – In the definition, “assembly of switchgear and controlgear” has been replaced with “assembly”, and at the end of the definition “and process data, etc.” has been added.]

3.1.5**busbar**

low-impedance conductor to which several electric circuits can be connected at separate points

Note 1 to entry: The term “busbar” is generic and does not presuppose the material, the geometrical shape, size or dimensions of the conductor(s).

[SOURCE: IEC 60050-151:2001, 151-12-30, modified – The text of the note has been replaced.]

3.1.6**main busbar**

busbar to which one or several distribution busbars and/or incoming and outgoing units are connected

Note 1 to entry: Conductors that are connected between a functional unit and a main busbar are not considered as a part of the main busbar.

3.1.7**distribution busbar**

busbar within one section which is connected to a main busbar and from which outgoing units are supplied

Note 1 to entry: Conductors that are connected between a functional unit and a distribution busbar are not considered as a part of the distribution busbars.

3.1.8**functional unit**

part of an assembly comprising all the electrical and mechanical elements including switching devices that contribute to the fulfilment of the same function

Note 1 to entry: The conductors connecting a functional unit to the main or distribution busbars and to the terminals for external conductors are part of the functional unit. Other conductors which are connected to a functional unit, but which are external to its compartment or enclosed protected space (e.g. auxiliary cables connected in a common compartment) are not considered to form part of the functional unit.

3.1.9

incoming unit

functional unit through which electrical energy is normally fed into the assembly

3.1.10

outgoing unit

functional unit through which electrical energy is normally supplied to one or more external circuits

3.1.11

short-circuit protective device

SCPD

device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

[SOURCE: IEC 60947-1:2020, 3.4.21]

3.1.12

current-limiting device

SCPD that, within a specified range of current, prevents the let-through current from reaching the prospective peak value and which limits the let-through energy (I^2t)

Note 1 to entry: The let-through current is also referred to as the cut-off current (see IEC 60050-441:2000, 441-17-12).

Note 2 to entry: Examples of current-limiting devices are current-limiting circuit-breakers in accordance with IEC 60947-2 and fuses in accordance with IEC 60269-2.

3.1.13

non-current-limiting device

SCPD that, within a specified range of current, allows the let-through current to reach the prospective peak value and which can have a rated short-time withstand current (I_{cw}) enabling it to withstand the let-through energy for the duration of the short-time current

3.1.14

line conductor

L

DEPRECATED: phase conductor (in AC systems)

DEPRECATED: pole conductor (in DC systems)

conductor which is energized in normal operation and capable of contributing to the transmission or distribution of electric energy but which is not a neutral or mid-point conductor

[SOURCE: IEC 60050-195:1998, 195-02-08]

3.1.15

relevant assembly standard

standard within the IEC 61439 series, Part 2 onwards, covering a generic type of assembly

EXAMPLE Power switchgear and controlgear assemblies (PSC-assemblies).

3.2 Constructional units of assemblies

3.2.1

fixed part

part consisting of components assembled and wired on a common support and which is designed for fixed installation

3.2.2**removable part**

part consisting of components assembled and wired on a common support which is intended to be removed entirely from the assembly and replaced whilst the main circuit to which it is connected may be live

3.2.3**connected position**

position of a removable part when it is fully connected for its intended function

3.2.4**removed position**

position of a removable part when it is outside the assembly, and mechanically and electrically separated from it

3.2.5**insertion interlock**

device preventing the introduction of a removable part into a location not intended for that removable part

3.2.6**fixed connection**

connection which can be connected with or without a tool and only disconnected by means of a tool

3.2.7**section**

constructional unit of an assembly between two successive vertical delineations

3.2.8**sub-section**

constructional unit of an assembly between two successive horizontal or vertical delineations within a section

3.2.9**compartment**

section or sub-section enclosed except for openings necessary for interconnection, control or ventilation

3.2.10**transport unit**

part of an assembly or a complete assembly suitable for transportation without being dismantled

3.2.11**shutter**

part of an assembly which can be moved between:

- a position in which it permits engagement of the contacts of a removable part with fixed contacts, and
- a position in which it becomes a part of a cover or a partition shielding the fixed contacts

[SOURCE: IEC 60050-441:2000, 441-13-07, modified – The text has been editorially reformatted into two bullet points.]

3.3 External design of assemblies

3.3.1

open-type assembly

assembly consisting of a supporting structure which supports the electrical equipment, the live parts of the electrical equipment being accessible

3.3.2

dead-front assembly

open-type assembly with a front cover, the live parts possibly being accessible from directions other than the front

3.3.3

enclosed assembly

assembly which is enclosed on all sides with the possible exception of its mounting surface in such a manner as to provide a defined degree of protection

3.3.4

cubicle-type assembly

enclosed assembly of the floor-standing type, which may comprise several sections, sub-sections or compartments

3.3.5

multi-cubicle-type assembly

combination of a number of mechanically joined cubicle-type assemblies

3.3.6

desk-type assembly

enclosed assembly with a horizontal or inclined control panel, or a combination of both, that incorporates control, measuring, and signalling apparatus, etc.

3.3.7

box-type assembly

enclosed assembly intended to be mounted on a vertical plane

3.3.8

multi-box-type assembly

combination of box-type assemblies mechanically joined together, with or without a common supporting frame, the electrical connections passing between two adjacent boxes through openings in the adjoining faces

3.3.9

wall-mounted surface type assembly

assembly for installation on the surface of a wall

3.3.10

wall-mounted recessed type assembly

assembly for installation into a wall recess, where the enclosure does not support the portion of wall above

3.3.11

floor-standing assembly

assembly for installation on the floor

3.4 Structural parts of assemblies

3.4.1

supporting structure

structure forming part of an assembly designed to support various components of the assembly and any enclosure

3.4.2

mounting structure

structure not forming part of an assembly, designed to support an assembly

3.4.3

mounting plate

plate designed to support various components and suitable for installation in an assembly

3.4.4

mounting frame

framework designed to support various components and suitable for installation in an assembly

3.4.5

enclosure

housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.4.6

cover

external part of the enclosure of an assembly

3.4.7

door

hinged or sliding cover

3.4.8

removable cover

cover which is designed for closing an opening in the external enclosure and which can be removed for carrying out certain operations and maintenance work

3.4.9

cover plate

part of an assembly which is used for closing an opening in the external enclosure and designed to be held in place by screws or similar means

Note 1 to entry: It is not normally removed after the equipment is put into service.

Note 2 to entry: The cover plate can be provided with cable entries.

3.4.10

partition

part of an assembly separating one compartment from other compartments

[SOURCE: IEC 60050-441:2000, 441-13-06]

3.4.11

barrier

part providing protection against direct contact from any usual direction of access

[SOURCE: IEC 60050-195:1998, 195-06-15, modified – “(electrically) protective” has been deleted from the term.]

3.4.12

obstacle

part preventing unintentional direct contact, but not preventing direct contact by deliberate action

Note 1 to entry: Obstacles are intended to prevent unintentional contact with live parts but not intentional contact by deliberate circumvention of the obstacle. They are intended to protect skilled, competent, authorised or instructed persons but are not intended to protect ordinary persons.

[SOURCE: IEC 60050-195:1998, 195-06-16, modified – “(electrically) protective” has been deleted from the term. Note 1 to entry has been added.]

3.4.13

terminal shield

part enclosing terminals and providing a defined degree of protection against access to live parts by persons or objects

3.4.14

cable entry

part with openings which permit the passage of cables into the assembly

3.4.15

protected space

part of an assembly intended to enclose electrical components, and which provides defined protection against external influences and contact with live parts

3.5 Conditions of installation of assemblies

3.5.1

assembly for indoor installation

assembly that is designed for use in locations where the normal service conditions for indoor use as specified in 7.1 apply

3.5.2

assembly for outdoor installation

assembly that is designed for use in locations where the normal service conditions for outdoor use as specified in 7.1 apply

3.5.3

stationary assembly

assembly that is designed to be fixed at its place of installation, for instance to the floor or to a wall, and to be used at this place

3.5.4

movable assembly

assembly which is designed so that it can readily be moved from one place of use to another

3.6 Insulation characteristics

3.6.1

clearance

shortest distance in air between two conductive parts

Note 1 to entry: This distance can be measured along a string stretched the shortest way between these conductive parts.

[SOURCE: IEC 60050-581:2008, 581-27-76, modified – Note 1 to entry has been added.]

3.6.2**creepage distance**

shortest distance along the surface of a solid insulating material between two conductive parts

Note 1 to entry: A joint between two pieces of solid insulating material is considered part of the surface.

[SOURCE: IEC 60050-151:2001, 151-15-50, modified – Note 1 to entry has been added.]

3.6.3**overvoltage**

voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

[SOURCE: IEC 60664-1:2007, 3.7]

3.6.4**temporary overvoltage**

overvoltage at power frequency of several seconds duration

3.6.5**transient overvoltage**

short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60050-614:2016, 614-03-14, modified – In the definition, “short duration overvoltage” has replaced “overvoltage with a duration”. Note 1 to entry and Note 2 to entry have been deleted.]

3.6.6**power-frequency withstand voltage**

RMS value of a power-frequency sinusoidal voltage which does not cause breakdown under specified conditions of test

[SOURCE: IEC 60947-1:2020, 3.7.55]

3.6.7**impulse withstand voltage**

highest peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified conditions

[SOURCE: IEC 60050-442:2014, 442-09-18]

3.6.8**pollution**

addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[SOURCE: IEC 60050-442:1998, 442-01-28, modified – In the definition, “can produce a permanent reduction of dielectric strength” has been replaced with “can result in a reduction of electric strength” and Note 1 to entry was deleted.]

3.6.9**pollution degree**

<of environmental conditions> conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt, and on the relative humidity and its frequency of occurrence resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity

Note 1 to entry: The pollution degree to which the insulating materials of devices and components are exposed may be different from that of the macro-environment where the assemblies are located because of protection offered by means such as an enclosure or internal heating to prevent absorption or condensation of moisture.

Note 2 to entry: For the purpose of this document, the pollution degree is of the micro-environment inside the assembly, unless otherwise stated in the applicable clause.

[SOURCE: IEC 60947-1:2020, 3.7.57, modified – Notes to entry have been adapted for the conditions associated with assemblies.]

3.6.10 environment

3.6.10.1 micro-environment

immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

Note 1 to entry: It is the effect of the micro-environment on the creepage and/or clearance distance that determines the selection of the insulation within the assembly. The micro-environment may be better or worse than the macro-environment.

[SOURCE: IEC 60050-851:2008, 851-15-16, modified – Note 1 to entry has been added.]

3.6.10.2 macro-environment

environment of the room or other location in which the assembly is installed or used

[SOURCE: IEC 60050-442:2014, modified – In the definition, the term “equipment” has been replaced by “assembly”.]

3.6.11 overvoltage category

<of a circuit or within an electrical system> conventional number based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending upon the means employed to influence the overvoltages

Note 1 to entry: In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements, such as an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category.

[SOURCE: IEC 60947-1:2020, 3.7.59]

3.6.12 surge protective device SPD

device designed to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently the amplitude of the follow-on current

[SOURCE: IEC 60947-1:2020, 3.4.22, modified – The term "surge arrester" was replaced with "surge protective device" and "SPD".]

3.6.13 insulation coordination

mutual correlation of insulating characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses

[SOURCE: IEC 60050-442:2014, modified – In the definition, ‘electrical’ has replaced ‘electric’.]

3.6.14**inhomogeneous field**

electric field which has not an essentially constant voltage gradient between electrodes

[SOURCE: IEC 60947-1:2020, 3.7.62]

3.6.15**tracking**

progressive formation of conducting paths which are produced on the surface of a solid insulating material, due to the combined effects of electric stress and electrolytic contamination on this surface

[SOURCE: IEC 60947-1:2020, 3.7.63]

3.6.16**comparative tracking index****CTI**

numerical value of the maximum voltage in volts which a material can withstand without tracking and without a persistent flame occurring under specified test conditions

Note 1 to entry: The value of each test voltage and the CTI should be divisible by 25.

[SOURCE: IEC 60947-1:2020, 3.7.64, modified – Note 1 to entry has been added.]

3.6.17**disruptive discharge**

phenomenon associated with the failure of insulation under electrical stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly zero

Note 1 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength; in a liquid or gaseous dielectric, the loss may be only temporary.

Note 2 to entry: The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric.

Note 3 to entry: The term "flashover" is used when a disruptive discharge occurs over the surface of a dielectric in a gaseous or liquid medium.

Note 4 to entry: The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

3.7 Protection against electric shock**3.7.1****live part**

conductive part intended to be energized under normal conditions, including a neutral conductor or mid-point conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

Note 1 to entry: This term does not necessarily imply a risk of electric shock. When the neutral conductor is effectively earthed it is not a hazardous live part and therefore not switched in TN-S or TN-C-S systems unless specifically required by other standards.

[SOURCE: IEC 61140:2016, 3.4, modified – Note 1 to entry has been replaced.]

3.7.2**hazardous live part**

live part which, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 61140:2016, 3.5, modified – Note 1 to entry was deleted.]

3.7.3

exposed-conductive-part

conductive part of the assembly, which can be touched and which is not normally live, but which can become live when basic insulation fails

Note 1 to entry: A conductive part of the assembly which can only become live through contact with an exposed-conductive-part which has become live, is not considered to be an exposed-conductive-part itself.

[SOURCE: IEC 60050-195:1998, 195-06-10, modified – In the definition, “equipment” has been replaced by “the assembly”. Note 1 to entry has been added.]

3.7.4

protective conductor

PE

conductor provided for purposes of safety, for example protection against electric shock

Note 1 to entry: As an example, the protective conductor can electrically connect the following parts:

- exposed-conductive-parts;
- extraneous conductive parts;
- main earthing terminal;
- earth electrode;
- earthed point of the source or artificial neutral.

Note 2 to entry: A protective conductor is sometimes referred to a protective earthing conductor.

[SOURCE: IEC 60050-826:2004, 826-13-22, modified – The note 1 has been replaced and note 2 added.]

3.7.5

neutral conductor

N

conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[SOURCE: IEC 60050-195:1998, 195-02-06, modified – The abbreviated term “N” has been added and “electric” was replaced with “electrical”.]

3.7.6

PEN conductor

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-195:1998, 195-02-12]

3.7.7

fault current

current resulting from an insulation failure, the bridging of insulation or incorrect connection in an electrical circuit

3.7.8

basic protection

protection against electric shock under fault-free conditions

Note 1 to entry: Basic protection is intended to prevent contact with live parts and generally corresponds to protection against direct contact.

[SOURCE: IEC 60050-195:1998, 195-06-01 modified – Note 1 to entry has been added]

3.7.9**basic insulation**

insulation of hazardous live parts, which provides basic protection

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEC 60050-826:2004, 826-12-14]

3.7.10**fault protection**

protection against electric shock under single-fault conditions

Note 1 to entry: Failure of basic insulation (3.7.9) is an example of a single fault condition.

Note 2 to entry: Fault protection generally corresponds to protection against indirect contact, mainly regarding failure of basic insulation.

[SOURCE: IEC 60050-195:1998, 195-06-02, modified – The notes to entry have been added.]

3.7.11**PELV system**

electric system in which the voltage cannot exceed the values given in IEC 60364-4-41:2005, Clause 414;

- under normal conditions and
- under single fault conditions, except earth faults in other electric circuits

Note 1 to entry: PELV is the abbreviation for protective extra low-voltage.

Note 2 to entry: The PELV circuits and/or exposed-conductive-parts of equipment supplied by the PELV circuits can be earthed.

[SOURCE: IEC 60050-826:2004, 826-12-32, modified – The IEC 60364-4-41:2005 reference has been added to the definition. Note 2 to entry has been added.]

3.7.12**SELV system**

electric system in which the voltage cannot exceed the values given in IEC 60364-4-41:2005, Clause 414:

- under normal conditions and
- under single fault conditions, including earth faults in other electric circuits

Note 1 to entry: SELV is the abbreviation for safety extra low-voltage.

Note 2 to entry: SELV circuits have basic insulation between live parts and earth.

[SOURCE: IEC 60050-826:2004, 826-12-31, modified – The IEC 60364-4-41:2005 reference has been added to the definition. Note 2 to entry has been added.]

3.7.13**(electrically) skilled person**

person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create

[SOURCE: IEC 60050-826:2004, 826-18-01]

3.7.14**competent person**

person who can judge the work assigned and recognize possible hazards on the basis of professional training, experience and knowledge of the relevant equipment

Note 1 to entry: Several years of practice in the relevant technical field may be taken into consideration in assessment of professional training.

[SOURCE: IEC 60050-851:2008, 851-11-10]

3.7.15

instructed person

person adequately advised or supervised by skilled persons to enable him or her to perceive risks and to avoid hazards electricity can create

[SOURCE: IEC 60050-826:2004, 826-18-02, modified – "(electrically)" was deleted from the main term.]

3.7.16

ordinary person

person who is neither a skilled person nor an instructed person

[SOURCE: IEC 60050-826:2004, 826-18-03]

3.7.17

authorized person

skilled or instructed person who is empowered to execute defined work

3.7.18

mid-point conductor

M

conductor electrically connected to the mid-point and capable of the transmission of electrical energy

Note 1 to entry: The term mid-point conductor is most frequently associated with DC applications.

[SOURCE: IEC 60050-195:1998, 195-02-07, modified – In the definition, "contributing to the distribution" has been replaced by "the transmission". Note 1 to entry has been added.]

3.7.19

PEM conductor

conductor combining the functions of both a protective earthing conductor and a mid-point conductor

[SOURCE: IEC 60050-195:1998, 195-02-13]

3.7.20

PEL conductor

conductor combining the functions of both a protective earthing conductor and a line conductor

[SOURCE: IEC 60050-195:1998, 195-02-14]

3.7.21

supplementary insulation

independent insulation applied in addition to basic insulation for fault protection

[SOURCE: IEC 60050-826:2004, 826-12-15]

3.7.22

double insulation

insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-826:2004, 826-12-16]

3.7.23

reinforced insulation

insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

Note 2 to entry: Reinforced insulation complies with IEC 60664-1:2007.

[SOURCE: IEC 60050-826:2004, 826-12-17, modified – New Note 2 to entry.]

3.7.24

class I assembly

assembly with at least one provision for a basic protection and a connection to a protective conductor as provision for a fault protection

Note 1 to entry: See IEC 61140:2016, 7.3 for further details.

Note 2 to entry: A class I assembly can have an insulated enclosure for basic protection and a protective conductor to facilitate fault protection for external circuits supplied through the class I assembly.

3.7.25

class II assembly

assembly which is provided with the following;

- basic insulation as provision for basic protection, and
 - supplementary insulation as provision for fault protection,
- or in which;
- basic protection and fault protection are provided by reinforced insulation

Note 1 to entry: See IEC 61140:2016, 7.4

3.8 Characteristics

3.8.1

nominal value

value of a quantity used to designate and identify a component, device, equipment or system

Note 1 to entry: The nominal value is generally a rounded value.

[SOURCE: IEC 60050-151:2001, 151-16-09]

3.8.2

limiting value

in a specification of a component, device, equipment or system, the greatest or smallest admissible value of a quantity

[SOURCE: IEC 60050-151:2001, 151-16-10]

3.8.3

rated value

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08]

3.8.4

rating

set of rated values and operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.8.5

nominal voltage

approximate value of voltage used to designate or identify an electrical system

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – Deletion of "(of a system)" from the term and addition of "electrical" in the definition.]

3.8.6

short-circuit current

I_c

overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit

[SOURCE: IEC 60050-441:2000, 441-11-07]

3.8.7

prospective short-circuit current

I_{cp}

current which would flow if the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the assembly

Note 1 to entry: For AC and DC applications, the current is the RMS value and the mean value in sustained conditions, respectively.

3.8.8

cut-off current

let-through current

I_{lt}

maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse

Note 1 to entry: This concept is of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

[SOURCE: IEC 60050-441:2000, 441-17-12]

3.8.9

voltage ratings

3.8.9.1

rated voltage

U_n

highest nominal voltage of the electrical system, declared by the assembly manufacturer, to which the main circuit(s) of the assembly is (are) designed to be connected

Note 1 to entry: In polyphase circuits, it is the voltage between lines.

Note 2 to entry: Transients are disregarded.

Note 3 to entry: The value of the supply voltage may exceed the rated voltage due to permissible system tolerances.

Note 4 to entry: The voltage is the RMS value and the mean value for AC and DC applications, respectively.

3.8.9.2**rated operational voltage** U_e

value of voltage, AC (RMS) or DC (mean value), declared by the assembly manufacturer for the assembly or a circuit of an assembly, which, combined with the rated current, determines its application

Note 1 to entry: In polyphase circuits, it is the voltage between lines.

3.8.9.3**rated insulation voltage** U_i

RMS withstand voltage value, assigned by the assembly manufacturer (3.10.2) to the assembly or to a circuit of an assembly, characterizing the specified (long-term) withstand capability of the insulation

Note 1 to entry: In polyphase circuits, it is the voltage between lines.

Note 2 to entry: The rated insulation voltage is not necessarily equal to the rated operational voltage of equipment, which is primarily related to functional performance.

[SOURCE: IEC 60664-1 2007, 3.9.1, modified – The symbol U_i has been added. In the definition, “manufacturer” has been replaced by “assembly manufacturer (3.10.2)” and ‘equipment or to a part of it’ has been replaced by ‘assembly or to a circuit of an assembly’. Note 1 to entry has been added.]

3.8.9.4**rated impulse withstand voltage** U_{imp}

impulse withstand voltage value, assigned by the assembly manufacturer for an assembly or a circuit of an assembly, characterizing the specified withstand capability of the insulation against transient overvoltages

[SOURCE: IEC 60664-1 2007, 3.9.2, modified – “withstand” has been added to term; the symbol U_{imp} has been added. In the definition, ‘to the equipment or to a part of it’ has been replaced by ‘for an assembly or a circuit of an assembly’.]

3.8.10**current ratings****3.8.10.1****rated current**

value of uninterrupted current, declared by the assembly manufacturer which can be carried without the temperature-rise of various parts of the assembly exceeding specified limits under specified conditions

Note 1 to entry: For rated current of the assembly (I_{nA}) see 3.8.10.7 and 5.3.1; for rated current of a main circuit (I_{nC}) see 3.8.10.5 and 5.3.2; and for group rated current of a main circuit (I_{ng}) see 3.8.10.6 and 5.3.3.

Note 2 to entry: Normally it is not necessary to take into account the inrush currents for motors, transformers, etc. when determining the rated current of a circuit.

3.8.10.2**rated peak withstand current** I_{pk}

value of peak short-circuit current declared by the assembly manufacturer, that can be withstood under specified conditions

3.8.10.3 rated short-time withstand current

I_{cw}
RMS value of AC or mean value of DC short-time current, declared by the assembly manufacturer, that can be withstood under specified conditions, defined in terms of current and time

Note 1 to entry: Rated short-time withstand current is not the same as an internal arc fault rating as given in IEC TR 61641.

3.8.10.4 rated conditional short-circuit current

I_{cc}
value of the prospective short-circuit current, declared by the assembly manufacturer, that can be withstood for the total operating time (clearing time) of the SCPD under specified conditions

3.8.10.5 rated current of a main circuit

I_{nc}
rated current which a main circuit can carry when it is the only main circuit within a section of an assembly that is carrying current

Note 1 to entry: The rated current of a main circuit can be lower than the rated currents of the devices installed in the main circuit, according to the respective device standards.

Note 2 to entry: Due to the complex factors determining the rated currents, no standard values can be given.

Note 3 to entry: An assembly can comprise of only a single section.

3.8.10.6 group rated current of a main circuit

I_{ng}
rated current which a main circuit can carry considering the mutual thermal influences of the other circuits that are simultaneously loaded in the same section of the assembly

Note 1 to entry: I_{ng} can equal I_{nc} in some designs of assembly.

Note 2 to entry: An assembly can comprise only a single section.

3.8.10.7 rated current of an assembly

I_{nA}
rated current which can be distributed by an assembly without the temperature-rise of any of the parts exceeding specified limits

Note 1 to entry: The rated current of the assembly is not to be exceeded if further circuits are added in the future.

3.8.10.8 design current (of an electric circuit)

I_B
electric current intended to be carried by an electric circuit in normal operation

Note 1 to entry: I_B is normally provided by the user.

[SOURCE: IEC 60050-826:2004, 826-11-10, modified – Note 1 to entry has been added.]

3.8.11 rated diversity factor RDF

value, calculated by dividing the group rated current of an outgoing main circuit I_{ng} by the rated current I_{nc} of the same outgoing main circuit, where I_{ng} and I_{nc} are derived by test

Note 1 to entry: RDF therefore represents the per unit value of I_{nc} , to which two or more outgoing circuits in the same section of an assembly can be continuously and simultaneously loaded taking into account the mutual thermal influences.

Note 2 to entry: For a group of circuits that are continuously and simultaneously loaded, the rated current of a circuit (I_{nc}) multiplied by the rated diversity factor (RDF) normally is not less than the design current (I_B) of the circuit normally provided by the user i.e. $I_{nc} \times RDF \geq I_B$.

3.8.12 **rated frequency**

f_n

value of frequency, declared by the assembly manufacturer, for which a circuit is designed and to which the operating conditions refer

Note 1 to entry: A circuit may be assigned a number or a range of rated frequencies or be rated for both AC and DC.

3.8.13 **electromagnetic compatibility** **EMC**

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

Note 1 to entry: For EMC related terms and definitions see Annex J.

[SOURCE: IEC 60050-161:2018, 161-01-07, modified – Note 1 to entry has been added.]

3.9 Verification

3.9.1 **design verification**

verification made on a sample of an assembly or on parts of assemblies to show that the design meets the requirements of the relevant assembly standard

Note 1 to entry: Design verification may comprise one or more equivalent methods. See 3.9.1.1, 3.9.1.2 and 3.9.1.3.

3.9.1.1 **verification test**

test conducted on a sample of an assembly or on parts of assemblies to verify that the design meets the requirements of the relevant assembly standard

Note 1 to entry: Verification tests are equivalent to type tests as in the IEC 60439 series of standards.

3.9.1.2 **verification comparison**

structured comparison of a proposed design for an assembly, or parts of an assembly, with a reference design(s) verified by test

3.9.1.3 **verification assessment**

design verification using strict design rules and/or calculations applied to an assembly or to parts of assemblies to show that the design meets the requirements of the relevant assembly standard

3.9.1.4 **reference design**

design of an assembly or parts of an assembly that has been verified by test

3.9.2

routine verification

verification of each assembly performed during and/or after manufacture to confirm whether it complies with the requirements of the relevant assembly standard

3.9.3

inspection

action comprising careful scrutiny, including visual scrutiny where conditions are obvious, of an item carried out either without dismantling, or with the addition of partial dismantling as required, supplemented by means such as measurement, in order to arrive at a reliable conclusion as to the condition of an item

[SOURCE: IEC 60050-426:2008, 426-14-02, modified – The definition has been modified.]

3.10 Manufacturer

3.10.1

original manufacturer

organization that has carried out the original design and the associated verification of an assembly in accordance with the relevant assembly standard

3.10.2

assembly manufacturer

organization taking the responsibility for the completed assembly

Note 1 to entry: The assembly manufacturer can be the same or a different organization to the original manufacturer.

3.11

user

party who will specify, purchase, use and/or operate the assembly, or someone acting on their behalf

4 Symbols and abbreviations

Alphabetical list of terms with symbols and abbreviations together with the subclause where they are first used:

Symbol/Abbreviation	Term	Term number
CTI	comparative tracking index	3.6.16
EMC	electromagnetic compatibility	3.8.13
f_n	rated frequency	3.8.12
I_c	short-circuit current	3.8.6
I_{cc}	rated conditional short-circuit current of an assembly or a circuit of an assembly	3.8.10.4
I_{lt}	cut-off current, let-through current	3.8.8
I_{cp}	prospective short-circuit current	3.8.7
I_{cw}	rated short-time withstand current	3.8.10.3
I_B	design current (of an electric circuit)	3.8.10.8
I_{nA}	rated current of an assembly	3.8.10.7
I_{nc}	rated current of a main circuit	3.8.10.5
I_{ng}	group rated current of a main circuit	3.8.10.6
I_{pk}	rated peak withstand current	3.8.10.2
L	line conductor	3.1.14
M	mid-point conductor	3.7.18
N	neutral conductor	3.7.5
PE	protective conductor	3.7.4
PEL	PEL conductor	3.7.20
PEM	PEM conductor	3.7.19
PELV	protective extra low-voltage	3.7.11
PEN	PEN conductor	3.7.6
RDF	rated diversity factor	3.8.11
SCPD	short-circuit protective device	3.1.11
SELV	safety extra low-voltage	3.7.12
SPD	surge protective device	3.6.12
U_e	rated operational voltage	3.8.9.2
U_i	rated insulation voltage	3.8.9.3
U_{imp}	rated impulse withstand voltage	3.8.9.4
U_n	rated voltage	3.8.9.1

5 Interface characteristics

5.1 General

The characteristics of the assembly shall ensure compatibility with the ratings of the circuits to which they are connected plus the installation conditions and shall be declared by the assembly manufacturer using the criteria identified in 5.2 to 5.6.

5.2 Voltage ratings

5.2.1 Rated voltage (U_n) (of the assembly)

The rated voltage shall be at least equal to the nominal voltage of the electrical system.

NOTE For further details on nominal system voltage see IEC 60038.

5.2.2 Rated operational voltage (U_e) (of a circuit of an assembly)

The rated operational voltage of any circuit shall not be less than the nominal voltage of the electrical system to which it is to be connected. If the nominal voltage is given for a three-phase system, the rated operational voltage of single-phase circuits shall not be less than the nominal voltage divided by $\sqrt{3}$.

If different from the rated voltage of the assembly, the appropriate rated operational voltage of the circuit shall be stated.

5.2.3 Rated insulation voltage (U_i) (of a circuit of an assembly)

The rated insulation voltage of a circuit of an assembly is the voltage value to which dielectric test voltages and creepage distances are referred.

The rated insulation voltage of a circuit shall be equal to or higher than the values stated for U_n and for U_e for the same circuit.

For single-phase circuits derived from IT systems (see IEC 60364-5-52:2009), the rated insulation voltage shall be at least equal to the voltage between the line conductors of the supply.

5.2.4 Rated impulse withstand voltage (U_{imp}) (of the assembly)

The rated impulse voltage of an assembly is the voltage value to which clearance distances and solid insulation withstand to transient overvoltage are referred.

The rated impulse withstand voltage shall be equal to or higher than the values stated for the transient overvoltages occurring in the electrical system(s) to which the circuit is designed to be connected.

The preferred values of rated impulse withstand voltage are those given in Table G.1.

5.3 Current ratings

5.3.1 Rated current of an assembly (I_{nA})

The rated current of an assembly is the lowest value of:

- the total group rated current I_{ng} of the incoming circuit(s), which is either the group rated current of the single incoming circuit or the sum of the group rated currents of the incoming circuits operated in parallel and simultaneously within the assembly;
- the total current that the main busbar can distribute in the particular assembly arrangement.

This current shall be carried without the temperature-rise of the individual parts exceeding the limits specified in 9.2.

NOTE 1 The group rated current of an incoming circuit can be lower than the rated current of the incoming device (according to the respective device standard) installed in the assembly.

NOTE 2 The main busbar in this context is a single busbar or a combination of single busbars that are normally connected in service e.g. by means of a bus-coupler.

5.3.2 Rated current of a main outgoing circuit (I_{nc})

The rated current of a main outgoing circuit is the current that can be carried by the outgoing circuit when all other outgoing main circuits in the same section are not carrying current (see 10.10). This current shall be carried without the temperature-rise of the various parts of the assembly exceeding the limits specified in 9.2.

Declaration of the rated current of a circuit I_{nc} is voluntary if the group rated current I_{ng} of the circuit is declared. If I_{nc} is stated, the maximum permissible continuous load current on an individual circuit in a lightly loaded section can be assessed and the load on the individual circuit possibly allowed to exceed I_{ng} , but it is never allowed to exceed I_{nc} .

NOTE I_{ng} represents the maximum permissible continuous load current in a fully loaded section.

5.3.3 Group rated current of a main circuit (I_{ng})

The group rated current of a main circuit is the current that can be carried by this circuit when it is loaded continuously and simultaneously together with at least one other circuit in the same assembly or section of the assembly, in a specific arrangement as defined by the original manufacturer. It shall be carried without the temperature-rise of the various parts of the assembly exceeding the limits specified in 9.2.

NOTE 1 Where the RDF for a design of assembly has been established in accordance with previous editions of IEC 61439 series, the I_{ng} can be calculated by $I_{nc} \times \text{RDF}$.

If I_{ng} is declared, the original manufacturer shall state the specific arrangements which are covered by the group rated current in terms of:

- type(s), ratings and maximum number of circuits/functional units allowed to be installed in the same assembly or section, and
- arrangement(s) of functional units within the sections and/or assemblies.

NOTE 2 For a functional unit with a given I_{ng} , the specific arrangement of assembly or section of an assembly can also be stated in terms of power loss.

NOTE 3 In most cases the same type of section provided by an original manufacturer can be equipped with a varying number and different types of circuits (functional units), depending on the needs of a specific customer. Usually, not all circuits installed in a section are required to carry their rated currents continuously and simultaneously. Therefore, the specific arrangement defined by the original manufacturer clarifies which situations are covered by a declared value of I_{ng} .

The group rated current of the main circuits, which are continuously and simultaneously loaded, shall be equal to or higher than the assumed loading of the outgoing circuits (equal to the design current I_B according to IEC 60364-1). The group rated current of the main circuits, which are continuously and simultaneously loaded, shall be equal to or higher than the assumed loading of the outgoing circuits (equal to the design current of the circuit, I_B , according to IEC 60364-1).

The assumed loading of outgoing circuits shall be addressed by the relevant assembly standard.

NOTE 4 The assumed loading of the outgoing circuits can be a steady continuous current or the thermal equivalent of a varying current (see Annex I).

I_{ng} is obtained by a test according to 10.10.2.3.5 or 10.10.2.3.6 or 10.10.2.3.7, or by calculation according to 10.10.4. Using method 10.10.2.3.6 or 10.10.2.3.7, I_{ng} values are required to calculate the RDF.

An alternative to declaring I_{ng} for each type of main circuit is to declare I_{nc} for each type of main circuit and the appropriate RDF.

5.3.4 Rated peak withstand current (I_{pk})

The rated peak withstand current shall be equal to or higher than the values stated for the peak value of the prospective short-circuit current of the supply system(s) to which the circuit(s) is (are) designed to be connected (see also 9.3.3).

5.3.5 Rated short-time withstand current (I_{cw}) (of a main circuit of an assembly)

The rated short-time withstand current of a main circuit of an assembly shall be equal to or higher than the prospective value of the short-circuit current I_{cp} at each point of connection to the supply (see also 3.8.10.3).

Different values of I_{cw} for different durations (e.g. 0,2 s; 1 s; 3 s) may be assigned to an assembly. Maximum duration normally does not exceed 1 s.

For AC, the value of the current is the RMS value of the AC component. For DC, the value of the current is the arithmetic mean value.

5.3.6 Rated conditional short-circuit current (I_{cc}) (of an assembly or a circuit of an assembly)

The rated conditional short-circuit current of an assembly or a circuit of an assembly, declared by the assembly manufacturer, is the maximum short-circuit current which that circuit when protected by a SCPD, as specified by the manufacturer, can satisfactorily withstand for the operating time of the device under the test conditions specified in 10.11.

The rated conditional short-circuit current of an assembly or a circuit of an assembly shall be equal to or higher than the prospective value of the short-circuit current I_{cp} for a duration limited by the operation of the short-circuit protective device that protects the circuit or assembly. The assembly manufacturer shall declare the breaking capacity, current limitation characteristics, I^2t and I_{lt} , of the specified short-circuit protective device, taking into consideration the data given by the device manufacturer.

5.4 Rated diversity factor (RDF)

As an alternative to declaring the group rated currents I_{ng} of each main outgoing circuit, their current carrying capacity under conditions of simultaneous operation can be stated in terms of the rated currents I_{nc} and the rated diversity factor.

The rated diversity factor is the per unit value of I_{nc} , to which outgoing circuits can be continuously and simultaneously loaded in the same section of the assembly in the specific arrangement(s) as defined by the original manufacturer, taking into account the mutual thermal influences. For further details on the specific arrangements, see 5.3.3.

NOTE 1 More information on RDF is given in Annex E.

The rated diversity factor multiplied by the rated current I_{nc} of the circuits shall be equal to or higher than the assumed loading of the outgoing circuits, where the assumed load current is equal to the design current I_B for continuously and simultaneously loaded circuits. If the design current I_B is not provided then the assumed loading of outgoing circuits shall be as given in the relevant assembly standard of IEC 61439 and is subject to agreement between user and manufacturer.

NOTE 2 The assumed loading of the outgoing circuits can be a steady continuous current or the thermal equivalent of a varying current (see Annex I).

5.5 Rated frequency (f_n)

The rated frequency of a circuit is the value of frequency to which the operating conditions are referred. Where the circuits of an assembly are designed for different values of frequency, the rated frequency of each circuit shall be given.

The frequency should be within the limits specified in the relevant IEC standards for the incorporated components. Unless otherwise stated by the assembly manufacturer, the limits are assumed to be 98 % and 102 % of the rated frequency.

5.6 Other characteristics

The following characteristics shall be declared:

- a) additional requirements depending on the use of a functional unit (e.g. type of coordination, overload characteristics);
- b) pollution degree of the macro-environment (see 3.6.10.2);
- c) types of earthing system for which the assembly is designed;
- d) indoor and/or outdoor installation (see 3.5.1 and 3.5.2);
- e) stationary or movable (see 3.5.3 and 3.5.4);
- f) degree of protection against contact with hazardous live parts, ingress of solid foreign bodies and water, IP code (see 8.2.2);
- g) intended for use by ordinary or authorized persons (see 3.7.16 and 3.7.17);
- h) electromagnetic compatibility (EMC) classification (see Annex J);
- i) special service conditions, if applicable (see 7.2);
- j) external design (see 3.3);
- k) degree of protection against mechanical impact, IK code, if applicable (see 8.2.1);
- l) type of construction – fixed or removable parts (see 8.5.1 and 8.5.2);
- m) type of short-circuit protective device(s) (see 9.3.2);
- n) measures for protection against electric shock;
- o) overall dimensions (including projections e.g. handles, covers, doors), if required;
- p) weight, if required.

6 Information

6.1 Assembly designation marking

The assembly manufacturer shall provide each assembly with one or more labels, marked in a durable manner and located in a place such that they are visible and legible when the assembly is installed and in operation. Compliance is checked according to the test of 10.2.7 and by inspection.

The following information regarding the assembly shall be provided on the designation label(s):

- a) assembly manufacturer's name or trade mark (see 3.10.2);
- b) type designation or identification number or any other means of identification, making it possible to obtain relevant information from the assembly manufacturer;
- c) means of identifying date of manufacture;
- d) rated current of the assembly I_{nA} (see 3.8.10.7 and 5.3.1);
- e) rated voltage of the assembly U_n (see 3.8.9.1 and 5.2.1);
- f) rated frequency of the assembly f_n (see 3.8.12 and 5.5);
- g) IEC 61439-X (the specific part "X" shall be identified).

NOTE The relevant assembly standard can specify where additional information is to be provided on the designation label.

6.2 Documentation

6.2.1 Information relating to the assembly

All interface characteristics according to Clause 5, where applicable, shall be provided in the assembly manufacturer's technical documentation supplied with the assembly.

6.2.2 Instructions for handling, installation, operation and maintenance

The assembly manufacturer shall provide in documents or catalogues the conditions, if any, for the handling, installation, operation and maintenance of the assembly and the equipment contained therein. Where appropriate, instructions shall state that the assembly manufacturer is to be consulted when repair of an assembly is required.

If necessary, the instructions shall indicate the measures that are of particular importance for the safe, proper and correct transport, handling, installation and operation of the assembly. The provision of weight details is of particular importance in connection with the transport and handling of transport units. In addition, installation instructions shall provide sufficient details for the installer to adequately secure the assembly in service.

The correct location and installation of lifting means and the thread size of lifting attachments, if applicable, shall be given in the assembly manufacturer's documentation or the instructions on how the transport unit has to be handled.

The measures to be taken, if any, with regard to EMC associated with the installation, operation and maintenance of the assembly shall be specified (see Annex J).

If an assembly specifically intended for environment A is to be used in environment B, a warning shall be included in the operating instructions, in accordance with the following:

CAUTION This product has been designed for environment A. Use of this product in environment B can cause unwanted electromagnetic disturbances, in which case the user may be required to take adequate mitigation measures.

Where necessary, the above-mentioned documents shall indicate the recommended extent and frequency of maintenance.

If the circuitry within the assembly is not obvious, for example, there are connections from several incoming power-supplies such as photovoltaic supplies, generators, batteries, information detailing the circuit arrangements shall be supplied.

When fuses are installed, the assembly manufacturer shall state the type and rating of the fuse-links to be used.

6.3 Device and/or component identification

Inside the assembly, it shall be possible to identify individual circuits and their protective devices. Identification tags shall be legible, permanent and appropriate for the physical environment. Any designations used shall be in compliance with IEC 81346-1:2009 and IEC 81346-2:2019 and identical to those used in the wiring diagrams, which shall be in accordance with IEC 61082-1:2014.

7 Service conditions

7.1 Normal service conditions

7.1.1 Climatic conditions

Assemblies conforming to this document are intended for use under the normal service conditions detailed in Table 15.

If components, for example relays, electronic equipment, are used which are not designed for these conditions, the environment provided within the assembly shall be suitable for the components.

7.1.2 Pollution degree

The pollution degree referred to in Annex C is the macro-environmental condition for which the assembly is intended.

For switching devices and components inside an enclosure, the pollution degree of the environmental conditions inside the enclosure, the micro-environment, is applicable.

For the purpose of evaluating clearances and creepage distances, the following four degrees of pollution in the micro-environment are established.

- Pollution degree 1:
No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
- Pollution degree 2:
Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.
- Pollution degree 3:
Conductive pollution occurs, or dry, non-conductive pollution occurs which is expected to become conductive due to condensation.
- Pollution degree 4:
Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

Pollution degree 4 is not applicable to this document for a micro-environment inside the assembly.

The micro-environment within the assembly can be different from the macro-environment outside the enclosure. The pollution degree for a particular type of assembly is given in the relevant assembly standard.

NOTE The pollution degree of the micro-environment for the equipment can be influenced by installation in an enclosure. When there is a need to open the assembly for normal service or operation the macro-environment of the installation can have an effect on the micro-environment.

7.2 Special service conditions

Where any special service conditions exist, the applicable particular requirements shall be complied with or special agreements shall be made between the assembly manufacturer and the user. The user shall inform the assembly manufacturer if such exceptional service conditions exist.

Special service conditions include, for example:

- a) values of temperature, relative humidity and/or altitude differing from those specified in 7.1;
- b) applications where variations in climatic conditions are likely to result in exceptional condensation inside the assembly;
- c) heavy pollution of the air by dust, smoke, corrosive or radioactive particles, vapours or salt;
- d) exposure to strong electric or magnetic fields;
- e) exposure to extreme climatic conditions;
- f) attack by fungus or small creatures;
- g) installation in locations where fire or explosion hazards exist;

- h) exposure to heavy vibration, shocks, seismic occurrences;
- i) installation in such a manner that the current-carrying capacity is affected, for example equipment built into machines or recessed into walls;
- j) exposure to conducted and radiated disturbances other than electromagnetic, and electromagnetic disturbances in environments other than those described in 9.4;
- k) exceptional overvoltage conditions or voltage fluctuations;
- l) excessive harmonics in the supply voltage or load current;
- m) exposure to radiation (for example, X-rays, microwave, ultraviolet other than solar, lasers).

7.3 Conditions during transport, storage and installation

A special agreement shall be made between the assembly manufacturer and the user if the conditions during transport, storage and installation, for example temperature and humidity conditions, differ from those defined in 7.1.

8 Constructional requirements

8.1 Strength of materials and parts

8.1.1 General

Under the responsibility of the original manufacturer, all design activities shall be carried out or supervised by a competent person.

The external shape of the assembly enclosure, if any, can vary to suit the application and use. Some examples are;

- cubicle-type assembly (see 3.3.4);
- multi-cubicle-type assembly (see 3.3.5);
- desk-type assembly (see 3.3.6);
- box-type assembly (see 3.3.7);
- multi-box-type assembly (see 3.3.8);
- wall-mounted surface type assembly (see 3.3.9);
- wall-mounted recessed type assembly (see 3.3.10); and
- floor-standing type assembly (3.3.11).

These enclosures may be constructed from various materials, e.g. insulating, metallic or a combination of these.

Assemblies shall be constructed of materials capable of withstanding the mechanical, electrical, thermal and environmental stresses that are likely to be encountered in specified service conditions.

In the case of special service conditions that can be present in the physical environment in which the assembly is to be installed (for example, dust, acids, corrosive gases, salts), the assemblies shall be adequately protected against contaminants (see Annex C). When the assembly is subject to radiation (for example, X-rays, microwave, ultraviolet, lasers), additional measures shall be taken to avoid malfunctioning of the assembly and accelerated deterioration of the insulation. When such measures are necessary, an agreement is required between the assembly manufacturer and the user.

When the assembly is subject to undesirable effects of vibration or shock, e.g. caused by a machine and its associated equipment, the selection of suitable equipment, or mounting it

away from the source of the vibration, or the provision of anti-vibration mountings shall be considered.

8.1.2 Protection against corrosion

Protection against corrosion shall be ensured by the use of suitable materials or by protective coatings to the exposed surface, taking account of the normal service conditions (see 7.1). Compliance with this requirement is checked by the test in 10.2.2.

8.1.3 Properties of insulating materials

8.1.3.1 Thermal stability

Enclosures or parts of enclosures made of insulating material(s), not already certified to their own product standard, e.g. louvers, meshes, shall be capable of operation at temperatures of at least 70 °C. Thermal stability shall be verified according to 10.2.3.1.

8.1.3.2 Resistance of insulating materials to heat and fire

8.1.3.2.1 General

Parts of insulating materials, which can be exposed to thermal stresses due to internal electrical effects, and the deterioration of which can impair the safety of the assembly, shall not be adversely affected by normal (operational) heat, and abnormal heat or fire.

8.1.3.2.2 Resistance of insulating materials to normal heat

The original manufacturer shall select insulating materials which are suitable for the maximum temperatures to which they are exposed in normal operation, in accordance with 9.2 and Table 6. The applied temperature-rise limit (see 9.2) for parts of insulating materials shall be justified based on, for example, the methods of IEC 60216 (all parts), or thermal class identified in accordance with IEC 60085:2007.

NOTE With recognition of the differences to other methods, insulating materials can also be selected based on the relative thermal index (RTI), UL 746B.

8.1.3.2.3 Resistance of insulating materials to abnormal heat and fire due to internal electric effects

Insulating materials used for parts necessary to retain current carrying parts in position and parts which can be exposed to thermal stresses due to internal electrical effects, of which the deterioration can impair the safety of the assembly, shall not be adversely affected by abnormal heat and fire and shall be verified by the glow-wire test in 10.2.3.2. For the purpose of this test, a protective conductor (PE) is not considered as a current-carrying part.

8.1.4 Resistance to ultra-violet (UV) radiation

External surfaces made of insulating material(s) and coated metal enclosures which are intended to be used outdoor exposed to ultra-violet radiation shall not crack nor deteriorate such that it impairs the safety of the assembly. Resistance to ultra-violet radiation shall be verified according to 10.2.4.

NOTE For assemblies exposed to UV radiation, other than solar radiation, the means of verification for resistance of the enclosures and external parts made of insulating material or external metal parts that are coated on their exposed surface(s) by synthetic material, are subject to agreement between the user and the manufacturer.

8.1.5 Mechanical strength

All enclosures or partitions, including locking means and hinges for doors, shall be of a mechanical strength sufficient to withstand the stresses to which they may be subjected in normal service, (see also 10.2.8) and during short-circuit conditions (see also 10.11).

The mechanical operation of removable parts, including any insertion interlock, shall be verified by test according to 10.2.8.

8.1.6 Lifting provision

Where lifting, other than by manual means is recommended by the manufacturer, e.g. by crane or fork lift truck, transport units shall be provided with the appropriate provision for lifting. Compliance is verified according to 10.2.5.

8.2 Degree of protection provided by an assembly enclosure

8.2.1 Protection against mechanical impact (IK code)

The minimum degree of protection provided by an assembly enclosure against mechanical impact, if necessary, shall be defined by the relevant assembly standards.

Compliance is verified according to 10.2.6.

8.2.2 Protection against contact with live parts, ingress of solid foreign bodies and water (IP code)

The degree of protection provided by any assembly against contact with live parts, ingress of solid foreign bodies and water is indicated by the IP code according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013; and verified according to 10.3.

After installation in accordance with the assembly manufacturer's instructions, the degree of protection of an enclosed assembly shall be at least IP2X. The degree of protection provided from the front of a dead-front assembly shall be at least IPXXB.

For assemblies for outdoor use having no supplementary protection, the second characteristic numeral shall be at least 3.

NOTE For outdoor installation, supplementary protection can be protective roofing or similar.

Unless otherwise specified, the degree of protection indicated by the assembly manufacturer applies to the complete assembly when installed in accordance with the assembly manufacturer's instructions, for example sealing of the open mounting surface of an assembly, etc.

Where the assembly does not have the same IP rating throughout, the assembly manufacturer shall declare the IP rating for the separate parts.

Different IP ratings shall not impair the intended use of the assembly.

EXAMPLES:

- operating face IP20, other parts IP00;
- drain holes in the base IPXXD, other parts IP43.

IP codes shall not be declared by the assembly manufacturer unless the appropriate verifications have been made according to 10.3.

Enclosed assemblies, for outdoor and indoor installation, intended for use in locations with high humidity and temperatures varying within wide limits, shall be provided with suitable arrangements (ventilation and/or internal heating, drain holes, etc.) to prevent harmful condensation within the assembly. However, the specified degree of protection shall at the same time be maintained.

8.2.3 Assembly with removable parts

The degree of protection (IP) indicated for assemblies normally applies to the connected position (see 3.2.3) of the removable parts.

If, after the removal of a removable part, it is not possible to maintain the original degree of protection (e.g. by closing a door), the assembly manufacturer shall make available covers or similar to restore the original degree of protection. If these measures are not available, the IP tests shall be carried out without the removable part in place.

When shutters are used to provide adequate protection to live parts, they shall be secured to prevent unintentional removal.

8.3 Clearances and creepage distances

8.3.1 General

The requirements for clearances and creepage distances are based on the principles of IEC 60664-1:2007 and are intended to provide insulation coordination within the installation.

NOTE Further information is available in IEC TR 60664-2-1:2011.

The clearances and creepage distances of equipment that form part of the assembly shall comply with the requirements of the relevant product standard.

When incorporating equipment into the assembly, the specified clearances and creepage distances shall be maintained during normal service conditions.

For dimensioning clearances and creepage distances between separate circuits, the highest voltage ratings shall be used (rated impulse withstand voltage for clearances and rated insulation voltage for creepage distances).

The clearances and creepage distances apply to line to line, line to neutral, and, except where a conductor is connected directly to earth, line to earth and neutral to earth.

For bare live conductors and terminations, the clearances and creepage distances shall at least be equivalent to those specified for the equipment with which they are directly associated.

The effect of a short-circuit up to and including the declared rating(s) of the assembly shall not reduce permanently the clearances or creepage distances between busbars and/or connections below the values specified for the assembly. Deformation of parts of the enclosure or of the internal partitions, barriers and obstacles due to a short-circuit shall not reduce permanently the clearances or creepage distances below those specified in 8.3.2 and 8.3.3 (see also 10.11.5.5).

8.3.2 Clearances

The clearances shall be sufficient to enable the declared rated impulse withstand voltage (U_{imp}) of a circuit to be achieved. The clearances shall be at least as specified in Table 1; if not, a design verification test and a routine impulse withstand voltage test are carried out in accordance with 10.9.3 and 11.3, respectively.

The method of determining clearances by measurement is given in Annex F.

8.3.3 Creepage distances

The original manufacturer shall select a rated insulation voltage(s) (U_i) for the circuits of the assembly from which the creepage distance(s) shall be determined. For any given circuit, the rated insulation voltage shall not be less than the rated operational voltage (U_e).

The creepage distances shall not, in any case, be less than the associated minimum clearances.

Creepage distances shall correspond to a pollution degree as specified in 7.1.2 and to the corresponding material group at the rated insulation voltage given in Table 2.

The method of determining creepage distances by measurement is given in Annex F.

For inorganic insulating materials, e.g. glass or ceramics, which do not track, creepage distances need not be greater than their associated clearances. However, the risk of disruptive discharge should be considered.

By using ribs of a minimum height of 2 mm, the creepage distance may be reduced but, irrespective of the number of ribs, shall be not less than 0,8 times the value of Table 2 and not less than the associated minimum clearance. The minimum base of the rib is determined by mechanical requirements (see Clause F.2).

8.4 Protection against electric shock

8.4.1 General

The apparatus and circuits in the assembly shall be so arranged as to facilitate their operation and maintenance with the required protection against electric shock.

The following requirements are intended to ensure that the required protective measures are obtained when an assembly is installed in an electrical system conforming to the IEC 60364 series.

NOTE For generally accepted protective measures, refer to IEC 61140:2016 and IEC 60364-4-41:2005, and IEC 60364-4-41:2005/AMD1:2017.

Those protective measures, which are of particular importance for an assembly, are reproduced in 8.4.2 to 8.4.6.

8.4.2 Basic protection

8.4.2.1 General

Basic protection is intended to provide protection against electric shock under normal conditions, preventing direct contact with hazardous live parts.

Basic protection can be achieved either by appropriate constructional measures on the assembly itself or by additional measures to be taken during installation; this may require information to be given by the assembly manufacturer.

An example of additional measures to be taken is the installation of an open-type assembly without further provisions in a location where access is only permitted for authorized person(s).

Where basic protection is achieved by constructional measures, one or more of the protective measures given in 8.4.2.2 and 8.4.2.3 may be selected. The choice of the protective measure shall be declared by the assembly manufacturer if not specified within the relevant assembly standard.

8.4.2.2 Basic insulation provided by insulating material

Hazardous live parts shall be completely covered with insulation that can only be removed by destruction or by the use of a tool.

The insulation shall be made of suitable materials capable of durably withstanding the mechanical, electrical and thermal stresses to which the insulation may be subjected in service.

EXAMPLES Electrical devices embedded in insulation and insulated conductors.

Paints, varnishes and lacquers alone are generally not considered to satisfy the requirements for basic insulation. This does not preclude the use of specifically designed insulating coatings that fulfil the dielectric requirements specified in 10.9.6.

8.4.2.3 Barriers or enclosures

Air-insulated live parts shall be inside enclosures or behind barriers. The enclosures or barriers shall provide a degree of protection of at least IPXXB.

Horizontal top surfaces of accessible enclosures having a height equal to or lower than 1,6 m above the standing area shall provide a degree of protection of at least IPXXD.

Barriers and enclosures shall be firmly secured in place and have sufficient stability and durability to maintain the required degrees of protection and appropriate separation from live parts under normal service conditions, taking account of relevant external influences. The distance between a conductive barrier or enclosure and the live parts they protect shall not be less than the values specified for the clearances and creepage distances in 8.3.

Where it is necessary to remove barriers or open enclosures or to remove parts of enclosures (see 8.4.6), this shall be possible only if one of the conditions a) to c) is fulfilled.

- a) By the use of a key or tool, i.e. any mechanical aid, to open the door, cover or override an interlock.
- b) After isolation of the supply to live parts, against which the barriers or enclosures afford basic protection, restoration of the supply being possible only after replacement or reclosure of the barriers or enclosures. In TN-C and TN-C-S systems, the PEL, PEM or PEN conductor shall not be isolated or switched. In TN-S and TN-C-S systems, the mid-point and neutral conductors need not be isolated or switched (see IEC 60364-5-53:2001, 536.1.2).

EXAMPLE By interlocking the door(s) with a disconnector so that they can only be opened when the disconnector is in the isolated position and closing of the disconnector without the use of a tool is impossible while the door is open.

- c) Where an intermediate barrier providing a degree of protection of at least IPXXB prevents contact with live parts, such a barrier being removable only by the use of a key or tool.

8.4.3 Fault protection

8.4.3.1 Installation conditions

The assembly shall include protective measures and be suitable for installations designed to be in accordance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017.

NOTE 1 Protective measure suitable for particular installations can be subject to additional or different requirements, e.g. for installation in ships as given in IEC 60092 series.

When a TT earthing system is being used in the electrical network, one of the following protective measures shall be applied in the assembly:

- a) double or reinforced insulation of all conductors (incoming cables, extension terminals, etc.) upto the supply side of the first RCD(s) in the system (this is not a requirement when a Class II assembly is used); or
- b) residual current device (RCD) protecting the incoming circuit.

NOTE 2 An equivalent to reinforced insulation can be provided by rigid connections, air and suitable mechanical protection.

Such provisions are subject to agreement between the user and the manufacturer.

8.4.3.2 Requirements for the protective conductor to facilitate automatic disconnection of the supply

8.4.3.2.1 General

Each assembly shall have a protective conductor to facilitate automatic disconnection of the supply for:

- a) protection against the consequences of earth faults within the class I assembly;
- b) protection against the consequences of earth faults in external circuits supplied through the class I and class II assembly. In the case of a class II assembly, the protective conductor may or may not be incorporated within the assembly: it is permissible for it to pass the assembly externally.

NOTE The enclosure can be or be part of the protective circuit.

The requirements to be complied with are given in 8.4.3.2.2 and 8.4.3.2.3.

Requirements for identification of the protective conductor (PE, PEN, PEM, PEL) are given in 8.6.6.

8.4.3.2.2 Requirements for earth continuity providing protection against the consequences of faults within the class I assembly

All exposed-conductive-parts of the assembly shall be interconnected together and to the protective conductor of the supply or via an earthing conductor to the earthing arrangement.

These interconnections may be achieved either by metal screwed connections, welding or other conductive connections, or by a separate conductor providing earth continuity.

With metal parts of the assembly where abrasion-resistant finishes are used (e.g. gland plates with powder coatings), interconnections providing earth continuity requires the removal or the penetration of the coating.

The method to verify the earth continuity between the exposed-conductive-parts of the assembly and the protective conductor is given in 10.5.2.

For the continuity of these connections, the following shall apply:

- a) When a part of the assembly is removed, for example for routine maintenance, the earth continuity for the remainder of the assembly shall not be interrupted.

Means used for assembling the various metal parts of an assembly are considered sufficient for ensuring earth continuity if the precautions taken guarantee permanent good conductivity.

Flexible or pliable metal conduits shall not be used as protective conductors unless they are designed for that purpose.

- b) For lids, doors, cover plates and the like, the usual metal screwed connections and metal hinges are considered sufficient to ensure continuity provided that no electrical equipment is attached to them except equipment which is part of a PELV or SELV system.

If devices with a voltage exceeding the limits of PELV or SELV systems, as appropriate, are attached to lids, doors, or cover plates, additional measures shall be taken to ensure earth continuity. These parts (lids, doors or covers) shall be fitted with a protective conductor (PE) whose cross-sectional area is in accordance with Table 3 depending on the highest rated operational current I_e of the devices attached. Alternatively, if the rated operational current of the attached devices is less than or equal to 16 A an equivalent electrical connection specifically designed and verified for this purpose shall be provided (e.g. sliding contact, hinges protected against corrosion).

Exposed conductive parts of a device that cannot be interconnected for earthing continuity by the fixing means of the device shall be connected to the earthing arrangement of the assembly by a conductor whose cross-sectional area is chosen according to Table 3.

Certain exposed-conductive-parts of an assembly that do not constitute a danger need not be connected to the earthing arrangement, either;

- because they cannot be touched on large surfaces or grasped with the hand; or
- because they are of small size (approximately 50 mm by 50 mm) or so located as to exclude any contact with live parts.

This applies to screws, rivets and nameplates. It also applies to electromagnets of contactors or relays, magnetic cores of transformers, certain parts of releases, or similar, irrespective of their size.

When removable parts are equipped with a metal supporting surface, these surfaces shall be considered sufficient for ensuring earth continuity provided that the pressure exerted on them is sufficiently high.

8.4.3.2.3 Requirements for protective conductors providing protection against the consequences of earth faults in external circuits supplied through the class I or class II assemblies

A protective conductor within the assembly shall be designed so that it can withstand the highest thermal and dynamic stresses arising from earth fault currents in external circuits supplied through the assembly in its installed location. Conductive structural parts may be used as a protective conductor or a part of it. Additional requirements for protective conductors for class II assemblies are given in 8.4.4 c).

Except where verification of the short-circuit withstand strength is not required in accordance with 10.11.2, verification shall be made in accordance with 10.5.3.

In principle, with the exception of the cases mentioned below, protective conductors within an assembly shall not include a disconnecting device (switch, disconnector, etc.).

- In the run of protective conductors, links shall be permitted which are removable by means of a tool and accessible only to authorized person(s) (these links may be required for certain tests).
- Where continuity can be interrupted by means of connectors or plug-and-socket devices, the protective circuit shall be interrupted only after the live conductors have been interrupted and continuity shall be established before the live conductors are reconnected.

In the case of an assembly containing structural parts, frameworks, enclosures, etc. made of conducting materials, a protective conductor, if provided, need not be insulated from these parts. Conductors to voltage-operated fault detection devices, including the conductors connecting them to a separate earth electrode, shall be insulated when specified by their manufacturer. This can also apply to the earth connection of the transformer neutral.

The cross-sectional area of protective conductors (PE, PEL, PEM, PEN) in an assembly to which external conductors are intended to be connected shall be not less than the value

calculated with the aid of the formula indicated in Annex B using the highest earth fault current and fault duration that may occur and taking into account the limitation of the SCPDs that protect the corresponding live conductors. The short-circuit withstand strength is verified according to 10.5.3.

For PEL, PEM and PEN conductors, the following additional requirements apply.

- The minimum cross-sectional area shall be 10 mm² for copper or 16 mm² for aluminium.
- The PEN and PEM conductor shall have a cross-sectional area not less than that required for a neutral and mid-point conductor (see 8.6.1).
- The PEN, PEL and PEM conductors need not be insulated within a class I assembly.
- Structural parts shall not be used as a PEN, PEL and PEM conductor; however, mounting rails according to IEC 60947-7-2:2009, Annex A, made of copper or aluminium may be used.

For details of requirements for terminals for external protective conductors, see 8.8.

8.4.3.3 Electrical separation

Electrical separation of individual circuits is intended to prevent electrical shock through contact with exposed-conductive-parts, which can become live when basic insulation of the circuit fails.

For this type of protection, see IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017.

8.4.4 Additional requirements for class II assemblies

- a) For basic and fault protection, by double or reinforced insulation, the following additional requirements shall be met. The electrical equipment shall be enclosed in insulating material which is equivalent of double or reinforced insulation. The enclosure shall carry the symbol  which shall be visible from the outside of the protected space.

NOTE 1 The enclosure can be the protected space or the protected space can be behind a barrier behind the door of an enclosure.

NOTE 2 The requirement of a class II assembly can be fulfilled by means of a metal enclosure separated from hazardous live parts and protective PEL, PEM and PEN conductors by double or reinforced insulation.

- b) The enclosure shall at no point be pierced by conducting parts in such a manner that there is the possibility of a fault voltage being brought out of the enclosure.

This means that metal parts, such as actuator shafts that, for constructional reasons, have to be brought through the enclosure, shall be insulated on the inside or the outside of the enclosure from the live parts for the maximum rated insulation voltage and the maximum rated impulse withstand voltage of all circuits in the assembly.

If an actuator, or similar, is made of metal (whether covered by insulating material or not), it shall be provided with insulation rated for the maximum rated insulation voltage and the maximum impulse withstand voltage of all circuits in the assembly.

- c) If an actuator, or similar, is principally made of insulating material, any of its metal parts which may become accessible in the event of insulation failure shall also be insulated from live parts for the maximum rated insulation voltage and the maximum rated impulse withstand voltage of all circuits in the assembly. The enclosure or protected space, when the class II assembly is ready for operation and connected to the supply, shall enclose all live parts, exposed-conductive-parts and parts belonging to a protective circuit in such a manner that they cannot be touched. The enclosure shall give at least the degree of protection IP2XC (see IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013).

If an external protective PEL, PEM or PEN conductor is passed through the class II assembly, the assembly should be provided with a suitably identified terminal.