

EXTENDED VERSION



This Extended version of IEC 61204-7:2016 includes the provisions of the general rules of IEC 62477-1:2012

Low-voltage switch mode power supplies – Part 7: Safety requirements



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Low-voltage switch mode power supplies – Part 7: Safety requirements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.200

ISBN 978-2-8322-3751-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCH MODE POWER SUPPLIES –

Part 7: Safety requirements

FOREWORD

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This Extended version of IEC 61204-7:2016 includes the provisions of the general rules dealt with in IEC 62477-1:2012. Clauses and subclauses of IEC 62477-1:2012 that are applicable in IEC 61204-7:2016 have been introduced in the content in red text.

International Standard IEC 61204-7 has been prepared by subcommittee 22E: Stabilized power supplies, of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a complete technical revision.

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

- a) use of IEC 62477-1 as reference document, instead of IEC 60950-1;
- b) modification of the title by deleting the wording “DC output-” and adding “switch mode”.

IEC 61204-7 has the status of a product standard.

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

FDIS	Report on voting
22E/175/FDIS	22E/177/RVD

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

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

A list of all parts in the IEC 61204 series, published under the general title *Low-voltage power supplies, d.c. output*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This International Standard is to be read in conjunction with IEC 62477-1:2012.

NOTE A consolidated version is under consideration.

Subclauses that are numbered starting from 100 are additional to those in IEC 62477-1:2012.

Additional tables and figures in this document are numbered starting from 100.

New annexes in this document are lettered AA, AB, AC, etc.

The wordings **SMPS** and “power supply” are considered to be identical throughout this document.

References of the reference document to clauses or tables, which have been modified in this document, shall be read as reference to the relevant clauses or tables of this document.

Refer to 3.100 for further information on how to read this document.

In this document, the following print types are used:

- Requirements proper and normative annexes: in roman type.
- Notes and other informative matter: in smaller roman type.
- Normative conditions within tables: in smaller roman type.
- Terms that are defined in clause 3 or IEC 62477-1:2012: **Bold Italic**.

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INTRODUCTION

IEC 62477-1:2012, used by this document as a reference, relates to products that include power electronic converters, with a rated system voltage not exceeding 1 000 V AC or 1 500 V DC. It specifies requirements to reduce risks of fire, electric shock, thermal, energy and mechanical hazards, except functional safety as defined in IEC 61508 (all parts). The objectives of this standard are to establish a common terminology and basis for the safety requirements of products that contain power electronic converters across several IEC technical committees.

IEC 62477-1:2012 was developed with the intention

- to be used as a reference document for product committees inside IEC technical committee 22: Power electronic systems and equipment in the development of product standards for power electronic converter systems and equipment,
- to replace IEC 62103 as a product family standard providing minimum requirements for safety aspects of power electronic converter systems and equipment in apparatus for which no product standard exists, and

NOTE The scope of IEC 62103 contains reliability aspects, which are not covered by this document.

- to be used as a reference document for product committees outside TC 22 in the development of product standards of power electronic converter systems and equipment intended for renewable energy sources. TC 82, TC 88, TC 105 and TC 114, in particular, have been identified as relevant technical committees at the time of publication.

As such, IEC technical sub-committee 22E: Stabilized switched-mode power supplies carefully considered the relevance of each paragraph of IEC 62477-1:2012 for the SMPS and referenced, added, replaced or modified requirements as relevant. This is because product-specific topics not covered by the reference document are the responsibility of the technical committee using the reference document.

The reference document, being a group safety standard, will not take precedence over this product-specific standard according to IEC Guide 104. IEC Guide 104 provides information about the responsibility of product committees to use group safety standards for the development of their own product standards.

LOW-VOLTAGE SWITCH MODE POWER SUPPLIES –

Part 7: Safety requirements

0 Principles of safety

Safety principles of this document follow the concepts of IEC Guide 116 and Annex D of CENELEC Guide 32:2014.

NOTE The principles of safety are mainly adopted from IEC 60950-1:2005/AMD1:2009/AMD2:2013.

0.1 General

The following principles have been adopted by IEC technical committee 22E in the development of this document. These principles do not cover performance or functional characteristics of equipment.

It is essential that designers understand the underlying principles of safety requirements in order that they can engineer safe equipment.

These principles are not an alternative to the detailed requirements of this document, but are intended to provide designers with an appreciation of the basis of these requirements. Where the equipment involves technologies, components and materials or methods of construction not specifically covered, the design of the equipment should provide a level of safety not less than that described in these principles of safety.

NOTE The need for additional detailed requirements to cope with a new situation is brought promptly to the attention of the appropriate committee.

Designers will take into account not only normal operating conditions of the equipment but also likely fault conditions, consequential faults, foreseeable misuse and external influences such as temperature, altitude, pollution, moisture, overvoltages on the **mains supply** and **non-mains supply**.

Dimensioning of insulation spacings should take account of possible reductions by manufacturing tolerances, or where deformation could occur due to handling, shock and vibration likely to be encountered during manufacture, transport and normal operation.

The following priorities should be observed in determining what design measures to adopt:

- where possible, specify design criteria that will eliminate, reduce or guard against hazards;
- where the above is not practicable because the functioning of the equipment would be impaired, specify the use of protective means independent of the equipment, such as personal protective equipment (which is not specified in this document);
- where neither of the above measures is practicable, or in addition to those measures, specify the provision of markings and instructions regarding the residual risks.

There are two types of persons whose safety needs to be considered, **operators** (or **users**) and **service persons**.

Operator is the term applied to all persons other than **service persons**. Requirements for protection should assume that **operators** are not trained to identify hazards, but will not intentionally create a hazardous situation. Consequently, the requirements will provide protection for cleaners and casual visitors as well as the assigned **operators**.

operators should not have access to hazardous parts, and to this end, such parts should only be in service access area or in equipment located in **restricted access areas**.

When **operators** are admitted to **restricted access areas (RAA)** they shall be suitably instructed.

NOTE The term "restricted access area" (RAA) is also known as "restricted access location" (RAL).

Service persons are expected to use their training and skill to avoid possible injury to themselves and others due to obvious hazards that exist in service access areas of the equipment or on equipment located in **restricted access areas**. However, **service persons** should be protected against unexpected hazards. This can be done by, for example, locating parts that need to be accessible for servicing away from electrical and mechanical hazards, providing shields to avoid accidental contact with hazardous parts, and providing labels or instructions to warn personnel about any residual risk.

Information about potential hazards can be marked on the equipment or provided with the equipment, depending on the likelihood and severity of injury, or made available for **service persons**. In general, **operators** shall not be exposed to hazards likely to cause injury, and information provided for **operators** should primarily aim at avoiding misuse and situations likely to create hazards, such as connection to the wrong power source and replacement of fuses by incorrect types.

Moveable equipment is considered to present a slightly increased risk of shock, due to possible extra strain on the supply cord leading to rupture of the earthing conductor. With hand-held equipment, this risk is increased; wear on the cord is more likely, and further hazards could arise if the units were dropped. **Transportable equipment** introduces a further factor because it can be used and carried in any orientation; if a small metallic object enters an opening in the **enclosure**, it can move around inside the equipment, possibly creating a hazard.

0.2 Hazards

0.2.1 General

Application of a safety standard is intended to reduce the risk of injury or damage due to the following:

- electric shock;
- energy related hazards;
- fire;
- heat related hazards;
- mechanical hazards;
- chemical hazards.

NOTE Radiation hazard are not included, as LEDs used for the purpose of indication and display only are not considered to cause hazardous radiation (e.g. like high intense lighting LEDs).

0.2.2 Electric shock

Electric shock is due to current passing through the human body. The resulting physiological effects depend on the value and duration of the current and the path it takes through the body. The value of the current depends on the applied voltage, the impedance of the source and the impedance of the body. The body impedance depends in turn on the area of contact, moisture in the area of contact and the applied voltage and frequency.

Currents of approximately half a milliamp can cause a reaction in persons in good health and may cause injury indirectly due to involuntary reaction. Higher currents can have more direct

effects such as burn or muscle tetanisation leading to inability to let go or to ventricular fibrillation.

It is normal to provide two levels of protection for **operators** to prevent electric shock. Therefore, the operation of equipment under normal conditions and after a single fault, including any consequential faults, should not create a shock hazard.

Harm may result from

- 1) contact with hazardous-live-parts,
- 2) breakdown of insulation between **hazardous-live-parts** and accessible conductive parts,
- 3) contact with circuits above **DVC As** limits,
- 4) breakdown of **operator** accessible insulation, and
- 5) **touch current** (leakage current) flowing from **hazardous-live-parts** to accessible parts, or failure of a **protective earthing** connection. **Touch current** may include current due to EMC filter components.

0.2.3 Energy related hazards

Injury or fire may result from a short-circuit between adjacent poles of high current supplies or high capacitance circuits, causing

- burns,
- arcing, and
- ejection of molten metal.

Even circuits whose voltages are safe to touch may be hazardous in this respect.

Examples of measures to reduce risks include:

- separation;
- shielding;
- provision of safety interlocks.

NOTE Safety interlocks are not described within this document.

0.2.4 Fire

Risk of fire may result from excessive temperatures either under normal operating conditions or due to overload, component failure, insulation breakdown or loose connections. Fires originating within the equipment should not spread beyond the immediate vicinity of the source of the fire, nor cause damage to the surroundings of the equipment.

Examples of measures to reduce risks include:

- providing overcurrent protection;
- using constructional materials having appropriate flammability properties for their purpose;
- selection of parts, components and consumable materials to avoid high temperature which might cause ignition;
- limiting the quantity of combustible materials used;
- shielding or separating combustible materials from likely ignition sources;
- using **enclosures** or barriers to limit the spread of fire within the equipment;
- using suitable materials for **enclosures** so as to reduce the likelihood of fire spreading from the equipment.

0.2.5 Heat related hazards

Injury may result from high temperatures under normal operating conditions, causing

- burns due to contact with hot accessible parts,
- degradation of insulation and of safety-critical components, and
- ignition of flammable liquids.

Examples of measures to reduce risks include:

- taking steps to avoid high temperature of accessible parts;
- avoiding temperatures above the ignition point of liquids;
- provision of markings to warn **operators** where access to hot parts is unavoidable.

0.2.6 Mechanical hazards

Injury may result from

- sharp edges and corners,
- moving parts that have the potential to cause injury,
- equipment instability,
- sonic pressure, and
- flying particles from exploding components (like electrolytic capacitors).

Examples of measures to reduce risks include:

- rounding of sharp edges and corners;
- guarding;
- providing sufficient stability to free-standing equipment;
- selecting suitable components, for example electrolytic capacitors with integral pressure relief to avoid explosion;
- provision of markings to warn **operators** where access is unavoidable.

0.2.7 Chemical hazards

Injury may result from contact with some chemicals or from inhalation of their vapours and fumes.

Examples of measures to reduce risks include:

- avoiding the use of constructional and consumable materials likely to cause injury by contact or inhalation during intended and normal conditions of use;
- avoiding conditions likely to cause leakage or vaporization;
- provision of markings to warn **operators** about the hazards.

0.3 Materials and components

Materials and components used in the construction of equipment should be so selected and arranged that they can be expected to perform in a reliable manner for the anticipated life of the equipment without creating a hazard, and would not contribute significantly to the development of a serious fire hazard. Components should be selected so that they remain within their manufacturers' ratings under normal operating conditions, and do not create a hazard under fault conditions.

1 Scope

1.1 Equipment covered by this document

This part of IEC 61204 specifies the safety requirements for **switch mode power supply (SMPS)** units supplied by source voltages up to 1 000 V AC or 1 500 V DC providing AC and/or DC output(s), except inverter output(s) establishing AC mains (see exceptions in 1.2).

NOTE 1 This document by definition covers DC-DC converters.

NOTE 2 Power supplies may provide accessory AC mains socket outlets, when such outputs are supplied from the AC mains.

This product standard covers both **stand-alone** and **component SMPS** as defined in this document. **DC power and distribution equipment** which provides, distributes, monitors, and controls isolated **secondary circuit** power to other equipment typically used in information and communication technology equipment installations (refer to Annex AC).

Equipment which is within the scope of Annex AC consists of some or all of the following:

- distribution panelboards, powerboards, disconnects, and overcurrent protective devices;
- control and monitoring equipment;
- assemblies consisting of: racks, shelves, and enclosures which could contain any of the above components, interconnecting hardware, **power supplies** (such as rectifiers, converters, and inverters), batteries, and any other related peripheral devices.

Where no standards exist, use of this document for other applications is not precluded.

1.2 Exclusions

This document does not cover:

- functional safety aspects as covered by for example IEC 61508 (all parts);
- reliability and risk considerations (e.g. related to power loss);
- information and communication technology equipment other than **SMPS** to such apparatus;
- electrical equipment and systems for railways applications and electric vehicles.
- motor-generator sets;
- uninterruptible power supplies (UPS);
- direct plug-in power units;
- power supplies according to IEC 61558 (all parts) covering linear power supply units incorporating safety isolating transformers providing **SELV** or **PELV** output(s) in accordance with IEC 60364-4-41 and **SMPS** for use with household and other consumer products;
- transformers covered by IEC 61558-1;
- step-down converters covered by IEC 60146-1-1;
- **SMPS** and converters for use with or in products covered by IEC 61347-2-2;
- **AC or DC mains supply** distribution equipment which is part of the building wiring system and not an integral part of the equipment used in **DC power and distribution equipment**, batteries, the design or installation of **DC power and distribution** conductors and other building installation wiring (not covered by Annex AC).

1.3 Additional requirements

Requirements additional to those specified in this document may be necessary for

- **SMPS** which comply with this document and satisfy the requirements of **SMPS** for use in or with other equipment, when referenced in such end product standards,
- **SMPS** intended for operation in special environments (for example, extremes of temperature; excessive dust, moisture or vibration (e.g. earth quake zones); flammable gases; and corrosive or explosive atmospheres),
- **SMPS** intended to be used in vehicles, on board ships or aircraft, or in tropical countries, and
- **SMPS** intended for use where ingress of water is possible; for guidance on such requirements and on relevant testing, see IEC 60529.

NOTE Attention is drawn to the fact that authorities in some countries impose additional requirements for health, environmental and similar reasons.

2 Normative references

Clause 2 of IEC 62477-1:2012 applies with the following exceptions/additions:

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 60227 (all parts), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

IEC 60245 (all parts), *Rubber insulated cables – Rated voltages up to and including 450/750 V*

IEC 60320 (all parts), *Appliance couplers for household and similar general purposes*

IEC 60384-14:2013, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417:2002 [online database], *Graphical symbols for use on equipment* [viewed 2016-06-24]. Available at <http://www.graphical-symbols.info/>

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60695-11-5, *Fire hazard testing Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-20:1999, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test methods*

IEC 60730-1:2010, *Automatic electrical controls – Part 1: General requirements*

IEC 60738-1:2009, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60747-5-5:2007, *Semiconductor devices – Discrete devices – Part 5-5: Optoelectronic devices – Photocouplers*

IEC 60799, *Electrical accessories – Cord sets and interconnection cord sets*

IEC 60851-3:2009, *Winding wires – Test methods – Part 3: Mechanical properties*

IEC 60851-5:2008, *Winding wires – Test methods – Part 5: Electrical properties*

IEC 60851-6:1996, *Winding wires – Test methods – Part 6: Thermal properties*

IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61058-1:2000, *Switches for appliances - Part 1: General requirements*

IEC 61058-1:2000/AMD1:2001

IEC 61058-1:2000/AMD2:2007

IEC 61293:1994, *Marking of electrical equipment with ratings related to electrical supply – Safety requirements*

IEC 61558-1:2005, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

IEC 61558-1:2005/AMD1:2009

IEC 61558-2 (all parts), *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V*

IEC 61810-1:2008, *Electromechanical elementary relays – Part 1: General requirements*

IEC 62368-1:2014, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

3 Terms and definitions

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

adjacent circuit

circuit next to the circuit under consideration having a requirement for functional, simple or protective *insulation*

3.2

basic insulation

insulation applied to hazardous live parts to provide basic protection against electric shock

[SOURCE: IEC 60050-195:1998, 195-06-06, modified]

3.3

basic protection

protection against electric shock under fault-free conditions

[SOURCE: IEC 60050-195:1998, 195-06-01]

3.4

commissioning test

test on a device or equipment performed on site, to prove the correctness of installation and operation

[SOURCE: IEC 60050-411:1996, 411-53-06, modified]

3.5

decisive voltage class

DVC

classification of voltage range used to determine the protective measures against electric shock and the requirements of *insulation* between circuits

3.6

double insulation

insulation comprising both basic insulation and supplementary insulation

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

3.7

DVC As

secondary circuit providing only safe to touch voltage, under normal and fault conditions and limited overvoltages

Note 1 to entry: For limits refer to Table 5.

Note 2 to entry: The limitation of overvoltage is not related to electric shock, but necessary due to interconnection of circuitry and possible affect to insulation relied on for safety.

3.8

DVC Ax

DVC Ax is the general **DVC** value used for **DVC A**, **DVC A1**, **DVC A2** or **DVC A3**

Note 1 to entry: Only **DVC As** is used within this document (refer to 3.100.5).

Note 2 to entry: Wherever IEC 62477-1:2012 uses the definition **DVC Ax**, it shall be read as **DVC As** in context with this document.

3.9

electrical breakdown

failure of *insulation* under electric stress when the discharge completely bridges the *insulation*, thus reducing the voltage between the electrodes almost to zero

[SOURCE: IEC 60664-1:2007, 3.20]

3.10

(electrical) insulation

electrical separation between circuits or conductive parts provided by clearance or creepage distance or solid *insulation* or combinations of them

3.11**(electronic) (power) conversion**

change of one or more of the characteristics of an electric power *system* essentially without appreciable loss of power by means of *power semiconductor devices*

Note 1 to entry: Characteristics are, for example, voltage, number of phases and frequency, including zero frequency.

[SOURCE: IEC 60050-551:1998, 551-11-02, modified]

3.12**enclosure**

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

Note 1 to entry: This standard provides requirement for the *enclosure* according to IEC 60529 as well as additional requirement for mechanical and environmental impact. The purpose of the additional requirement is to ensure the *enclosures* ability to provide *basic protection* under the environmental conditions specified by the manufacturer.

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

3.13**enhanced protection**

protective provision having a reliability of protection not less than that provided by two independent protective provisions

3.14**expected lifetime**

design duration for which the performance characteristics are valid at rated conditions of operation

3.15**extra-low voltage****ELV**

voltage not exceeding the relevant voltage limit of band I specified in IEC 60449

Note 1 to entry: In IEC 60449, band I is defined as not exceeding 50 V a.c. r.m.s. and 120 V d.c. Other product committees may have defined *ELV* with different voltage levels.

Note 2 to entry: In this standard, protection against electric shock is dependent on the *decisive voltage classification*.

[SOURCE: IEC 60050-826:2004, 826-12-30, modified]

3.16**fault protection**

protection against electric shock under single-fault conditions

Note 1 to entry: For low-voltage *installations, systems* and equipment, *fault protection* generally corresponds to protection against indirect contact as used in IEC 60364-4-41, mainly with regard to failure of *basic insulation*.

[SOURCE: IEC 60050-195:1998, Amendment 1:1998, 195-06-02]

3.17**field wiring terminal**

terminal provided for connection of external conductors to the *SMPS*

3.18**fire enclosure**

part of the equipment intended to minimize the spread of fire or flames from within

3.19**functional insulation**

insulation between conductive parts within a circuit that is necessary for the proper functioning of the circuit, but which does not provide protection against electric shock

Note 1 to entry: *Functional insulation* may, however, reduce the likelihood of ignition and fire.

3.20**hazardous-live-part**

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

[SOURCE: IEC 60050-195:1998, 195-06-05]

3.21**installation**

equipment or equipments including at least the **SMPS**

Note 1 to entry: The word *installation* is also used in this standard to denote the process of installing a **SMPS**. In these cases, the word does not appear in italics.

3.22**live part**

conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a *protective earth conductor* or *protective earth neutral*

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19, modified]

3.23**low voltage****LV**

set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V a.c. or 1 500 V d.c.

[SOURCE: IEC 60050-601:1985, 601-01-26, modified]

3.24**mains supply**

power distribution system that is either an AC **mains supply** or a DC **mains supply**

3.25**muscular reaction (inability to let go)**

physiological reaction due to a minimum derived value of touch voltage for a population for which a current flowing through the body is just enough to cause involuntary contraction of a muscle, such as inability to let go from an electrode, but not including *startle reaction*

[SOURCE: IEC/TR 60479-5:2007, 3.3.2, modified]

3.26**non-mains supply**

electrical circuit that is not energized directly from the **mains supply**, but is, for example, isolated by a transformer or supplied by a battery, generator, or similar sources not directly connected to the a.c. power distribution **system**

3.27**open type**

product intended for incorporation within *enclosure* or assembly that will provide protection against hazards

3.28**output short circuit current**

available current r.m.s or d.c. that flows at the output of the *SMPS* when a short circuit is applied by a conductor of negligible impedance

3.29**PELV (system)**

electric system in which the voltage cannot exceed the value of *extra low voltage*:

- 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*.

[SOURCE: IEC 60050-826:2004, 826-12-32]

3.30**permanently connected (equipment)**

equipment that is intended for connection to the building *installation* wiring using screw terminals or other reliable means

3.31**pluggable equipment type A**

equipment that is intended for connection to the *mains supply* via a non-industrial plug and socket-outlet or a non-industrial appliance coupler, or both

3.32**pluggable equipment type B**

equipment that is intended for connection to the *mains supply* via an industrial plug and socket-outlet or an appliance coupler, or both, complying with IEC 60309 or with a comparable national standard

3.33**port**

access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

[SOURCE: IEC 60050-131:2002, 131-12-60]

3.34**power semiconductor device**

semiconductor device used for *electronic power conversion*

3.35**prospective short circuit current**

available current that flows when a short circuit is applied by a conductor of negligible impedance

3.36**protective-equipotential-bonding**

equipotential bonding for purposes of safety (e.g. protection against electric shock)

[SOURCE: IEC 60050-195:1998, 195-01-15, modified]

3.37**protective class I**

equipment in which protection against electric shock does not rely on *basic insulation* only, but which includes an additional safety precaution in such a way that means are provided for

the connection of accessible conductive parts to the *protective (earthing) conductor* in the fixed wiring of the *installation*, so that accessible conductive parts cannot become live in the event of a failure of the *basic insulation*

3.38

protective class II

equipment in which protection against electric shock does not rely on *basic insulation* only, but in which additional safety precautions such as *supplementary insulation* or *reinforced insulation* are provided, there being no provision for *protective earthing* or reliance upon *installation* conditions

3.39

protective class III

equipment in which protection against electric shock relies on supply at **DVC As** and in which voltages higher than those of **DVC As** are not generated and there is no provision for **protective earthing**

3.40

protective earthing

PE

earthing of a point in a *system*, or equipment, for protection against electric shock in case of a fault

3.41

PE conductor

conductor in the building *installation* wiring, or in the power supply cord, connecting a main *protective earthing* terminal in the equipment to an earth point in the building *installation* for safety purposes

3.42

protective impedance

impedance connected between *hazardous live parts* and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions, is limited to a safe value, and which is so constructed that its ability is maintained throughout the life of the equipment

[SOURCE: IEC 60050-442:1998, 442-04-24, modified]

3.43

(electrically) protective screening

separation of circuits from hazardous live-parts by means of an interposed conductive screen, connected to the means of connection for a *PE conductor*, either directly or via *protective equipotential bonding*

3.44

(electrically) protective separation

separation of one electric circuit from another by means of:

- *double insulation* or
- *basic insulation* and electrically *protective screening* or
- *reinforced insulation*

[SOURCE: IEC 60050-195:1998, Amendment 1:1998, 195-06-19]

3.45

power electronic converter

PEC

device or part thereof for the purpose of *electronic power conversion*, including signalling, measurement, control circuitries and other parts, if essential for the *power conversion function*

3.46**power electronic converter system****PECS**

one or more *power electronic converters* intended to work together with other equipment

3.47**reinforced insulation**

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

[SOURCE: IEC 60664-1:2007, 3.17.5]

3.48**restricted access area**

area accessible only to electrically skilled persons and electrically instructed persons with the proper authorization

Note 1 to entry: An electrically skilled person is a person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create

Note 2 to entry: An electrically instructed person is a person adequately advised or supervised by electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create

[SOURCE: IEC 60050-195:1998, 195-04-04, modified]

3.49**routine test**

test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60050-411:1996, 411-53-02, modified]

3.50**sample test**

test on a number of devices taken at random from a batch

3.51**SELV (system)**

electric system in which the voltage cannot exceed the value of *extra-low voltage*:

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

NOTE SELV is the abbreviation for safety *extra low voltage*.

[SOURCE: IEC 60050-826:2004, 826-12-31, modified]

3.52**short circuit backup protection**

protection that is intended to operate when other protective measures within a *system* or equipment fail to clear a fault

3.53**simple separation**

separation between electric circuits or between an electric circuit and local earth by means of *basic insulation*

[SOURCE: IEC 60050-826:2004, 826-12-28]

3.54**single fault condition**

condition in which one failure is present which could cause a hazard covered by this standard

Note 1 to entry: If a *single fault condition* results in other subsequent failures, the set of failures is considered as one *single fault condition*.

Note 2 to entry: Examples of hazards include, but are not limited to electric shock, fire, energy, mechanical, sonic pressure etc.

3.55**startle reaction**

physiological reaction due to a minimum derived value of touch voltage for a population for which a current flowing through the body is just enough to cause involuntary muscular contraction to the person through which it is flowing

[SOURCE: IEC/TR 60479-5:2007, 3.3.1, modified]

3.56**supplementary insulation**

independent *insulation* applied in addition to *basic insulation for fault protection*

Note 1 to entry: *Basic* and *supplementary insulation* are separate, each designed for *simple separation* against electric shock.

[SOURCE: IEC 60664-1: 2007, 3.17.3, modified]

3.57**surge protective device****SPD**

device that contains at least one non-linear component that is intended to limit surge voltages and divert surge currents

Note 1 to entry: An SPD is a complete assembly, having appropriate connecting means.

[SOURCE: IEC 61643-11:2011, 3.1.1]

3.58**system**

set of interrelated and/or interconnected independent elements

Note 1 to entry: A *system* is generally defined with the view of achieving a given objective, for example by performing a definite function.

3.59**system voltage**

voltage used to determine *insulation* requirements

Note 1 to entry: See 4.4.7.1.6 for further consideration of *system voltage*.

3.60**temporary overvoltage**

overvoltage at power frequency of relatively long duration

[SOURCE: IEC 60664-1:2007, 3.7.1]

3.61**touch current**

electric current passing through a human body or through an animal body when it touches one or more accessible parts of an electrical *installation* or electrical equipment

[SOURCE: IEC 60050-826:2004, 826-11-12]

3.62**type test**

test of one or more devices made to a certain design to show that the design meets certain specifications

[SOURCE: IEC 60050-811:1991, 811-10-04]

3.63**ventricular fibrillation**

cardiac fibrillation, limited to the ventricles, leading to ineffective circulation and then to heart failure

Note 1 to entry: Ventricular fibrillation stops blood circulation.

[SOURCE: IEC 60050-891:1998, 891-01-16]

3.64**working voltage**

voltage, at rated supply conditions (without tolerances) and worst case operating conditions, that occurs by design in a circuit or across *insulation*

Note 1 to entry: The *working voltage* can be d.c. or a.c. Both the r.m.s. and recurring peak values are used.

3.65**zone of equipotential bonding**

zone where all simultaneously accessible conductive parts are electrically connected to prevent hazardous voltages appearing between them

Note 1 to entry: For equipotential bonding, it is not necessary for the parts to be earthed.

3.100 General

The terms and definitions of **SELV/PELV** circuits are inconsistent throughout the standards. Therefore the definition for **DVC** circuits has been introduced. Where references are made of this document to clauses of the IEC 62477-1:2012 containing requirements for **SELV** and **PELV** circuits, such requirements shall be disregarded. Refer also to 4.4.6.4.2 for further details.

3.100.1**abnormal operation conditions**

temporary operating condition that is not a normal operating condition and is not a single fault condition of the equipment itself

Note 1 to entry: An abnormal operating condition may be introduced by the equipment or by a person and may result in a failure of a component, a device or insulation.

3.100.2**AC mains supply**

low voltage AC power distribution system for supplying power to AC equipment

3.100.3**DC mains supply**

a DC power distribution system, with or without batteries, external to the equipment, for supplying power to DC powered equipment at hazardous energy level (> 240 VA after 60 s)

3.100.4**DC power and distribution equipment**

equipment to supply DC power to information and communication technology equipment

Note 1 to entry: Normally consisting of batteries, power supplies, control and monitoring circuits, and distribution panels all interconnected to provide isolated secondary circuit power to information and communication technology equipment loads. Components within this system are normally installed in racks, cabinets, or other structures

3.100.5

DVC B

secondary circuit which stays in certain voltage limits under normal and fault conditions

Note 1 to entry: Refer to Table 5.

3.100.6

DVC C

any circuit not meeting the separation requirements or voltage limits for **DVC B** or **DVC As**

3.100.7

electric strength

dielectric strength

ability of the insulation against the effects of the electric field as investigated by electric strength tests

Note 1 to entry: Any reference to electric strength tests made within this document refers to both an impulse voltage test and an AC and DC voltage test.

Note 2 to entry: An AC and DC voltage test can be used alternatively to an impulse voltage test as described in 5.2.3.3, see 5.2.3.4 for details.

3.100.8

auxiliary socket-outlet

mains socket-outlet

AC output which is either directly connected or via EMC filtering components, AC switches or fuses to the **AC mains supply**

3.100.9

moveable equipment

equipment that is either

- 18 kg or less in mass and not fixed in place, or
- provided with wheels, casters, or other means to facilitate movement by an ordinary person as required to perform its intended use

3.100.10

operator

user

any person, other than a **service person**

3.100.11

secondary circuit

circuit that has no direct connection to a AC mains circuit and derives its power from a transformer, converter or equivalent isolation device, from a battery or DC mains

3.100.12

service person

person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons

3.100.13

stand-alone switch-mode power supply

switch mode power supply (SMPS) that in itself is an end use product

3.100.14**stationary equipment**

- fixed equipment, or
- permanently connected equipment, or
- equipment that, due to its physical characteristics, is normally not moved

Note 1 to entry: Stationary equipment is neither movable equipment nor transportable equipment.

3.100.15**switch-mode power supply****SMPS**

an electrical or electronic device, incorporating a switching regulator to efficiently convert electrical power, transforming electrical power into single or multiple power outputs

Note 1 to entry: It may also isolate, regulate and/or convert the power. This may consist of one or more individual **SMPS** with associated circuitry and hardware.

3.100.16**component SMPS**

switch mode power supply (SMPS) which may not comply with some of the requirements of the standard such as **enclosure** requirements

Note 1 to entry: This type of **SMPS** is intended for incorporation within an end product, which in turn complies with all the requirements of the end product standard.

3.100.17**transportable equipment**

equipment that is intended to be routinely carried

4 Protection against hazards

The provisions of Clause 4 of IEC 62477-1:2012 apply, except as follows.

4.1 General

Replacement:

Clause 4 defines the minimum requirements for the design and construction of a SMPS, to ensure its safety during installation, normal operating conditions and maintenance for the expected lifetime of the SMPS. Consideration is also given to minimising hazards resulting from reasonably foreseeable misuse.

Protection against hazards shall be maintained under normal and single fault conditions, as specified in this document.

Components compliant with a relevant IEC product standard which provides similar safety requirements as the requirement of this document do not require separate evaluation.

Components or assemblies of components, for which no relevant product standard exists, shall be tested according to the requirements of this document.

Where the SMPS is intended to be used together with specific auxiliary equipment, the safety evaluation and test shall include this auxiliary equipment unless it can be shown that it does not affect the safety of either equipment.

Addition:

4.1.100 Constructions not specifically covered

Where the equipment involves technologies and materials or methods of construction not specifically covered in this document, the equipment shall provide a level of safety not less than that generally afforded by this document and the principles of safety contained herein.

NOTE The need for additional detailed requirements to cope with a new situation is brought promptly to the attention of the appropriate committee.

4.1.101 Orientation during transport and use

4.1.101.1 General

Where it is clear that the orientation of the equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use permitted in the installation or operating instructions shall be taken into account. For **transportable equipment**, all orientations of transport and use shall be taken into account.

4.1.101.2 Choice of criteria

Where the standard permits a choice between different criteria for compliance, or between different methods or conditions of test, the choice is specified by the manufacturer.

4.1.101.3 Conductive liquids

For the electrical requirements of this document, conductive liquids shall be treated as conductive parts.

4.2 Fault and abnormal conditions

Replacement:

The SMPS shall be designed to avoid operating modes or sequences that can cause a fault condition or component failure leading to a hazard, unless other measures to prevent the hazard are provided by the installation and are described in the installation information provided with the SMPS. The requirements in this clause also apply to abnormal operating conditions as applicable.

Circuit analysis or testing shall be performed to determine whether or not failure of a particular component (including insulation systems) would result into hazard.

This analysis shall include situations where a failure of the component or any insulation other than **double** or **reinforced insulation** would result in

- an impact on the decisive voltage classification voltage limits (Table 5),
- a risk of electric shock due to an impact on any of the methods for protection against electric shock according to 4.4,
- a risk of energy hazard according to 4.5,
- a risk of degradation due to emission of flame, burning particles or molten metal of the fire according to 4.6,
- a risk of thermal hazard due to high temperature according to 4.6, and
- a risk of mechanical hazard according to 4.7.

The effects of short circuit and open-circuit conditions of the component or between components or between printed wiring board (PWB) traces shall be considered. Testing is necessary unless analysis can conclusively show that no hazard will result in case of the these failure modes. Compliance shall be checked by investigation or test of 5.2.4.6.

The evaluation of components shall be based on the expected stress occurring in the expected lifetime of the SMPS including, but not limited to

- specified climatic and mechanical conditions according to 4.9 (temperature, humidity, vibration, etc.),
- electrical characteristics according to 4.4.7 (expected impulse voltage, working voltage, temporary overvoltage, etc.), and
- micro environment according to 4.4.7 (pollution degree, humidity, etc.).

Components shall meet the requirements of Clause 7.

Clearance and creepage distances, dimensioned to 4.4.7.4 and 4.4.7.5 and/or solid insulation dimensioned to 4.4.7.8 for **double** or **reinforced insulation** does not need to be faulted.

Functional insulation on PWB and between legs of components assembled on PWBs not fulfilling the requirements for clearance and creepage distance in 4.4.7.4 and 4.4.7.5 shall meet the requirement of 4.4.7.7.

Addition:

4.2.100 Application of faults and abnormal conditions

A single fault consists of a single failure of any insulation (excluding **double insulation** or **reinforced insulation**) or a single failure of any component (excluding components with **double insulation** or **reinforced insulation**).

The equipment construction, circuit diagrams, component specifications, including **functional insulation** are examined to determine those **single fault conditions** that might reasonably be expected. In particular:

- short-circuits and open circuits of semiconductor devices and capacitors;
- faults causing continuous dissipation in resistors designed for intermittent dissipation;
- internal faults in integrated circuits causing excessive dissipation;
- failure of **functional** or **basic insulation**, where this might affect
 - accessible conductive parts;
 - earthed conductive screens;
 - parts of **DVC As** circuits;
 - parts of limited current circuits described in clause 4.4.5.102.
- as a minimum, the following examples of abnormal operating conditions shall be considered, as applicable:
 - for equipment with controls accessible to an user, adjustment of the controls, both individually and collectively, for worst-case operating conditions;
 - applicable testing as indicated in Table 22;
- fault conditions as described in IEC 60990:1999, 6.2.2.
- any other faults or conditions that might affect the safety of the power supply.

4.3 Short circuit and overload protection

4.3.1 General

The **SMPS** shall not present a hazard, under short circuit or overload conditions at any *port*, including phase to phase, phase to earth and phase to neutral. Adequate information shall be provided in the documentation to allow proper selection of external wiring and protective devices (see 6.3.7.6 and 6.3.7.7).

Protective *systems* or devices shall be provided or specified in sufficient quantity and location so as to detect and to interrupt or limit the current flowing in any possible fault current path between conductors or from conductors to earth.

NOTE 1 In this standard, the term overcurrent covers both short circuit and overload.

NOTE 2 Local *installation* codes will still usually require provision of such protection for the purposes of protecting the input wiring in the *installation*.

Protection against overcurrents shall be provided for all input circuits, and for output circuits that do not comply with the requirements for limited power sources in 4.6.5.

If the **SMPS** complies with all normal, abnormal and fault test conditions in this standard without such protection provided, provision or specification of overcurrent protection for input circuits is not necessary for the protection of the **SMPS**.

No protection is required against overcurrent to earth in equipment that either

- has no connection to earth; or
- has *double insulation* or *reinforced insulation* between *live parts* and all parts connected to earth.

NOTE 3 Under a *single fault condition* in an IT system no short circuit current or a limited short circuit current will flow. The interruption of the short circuit current in an IT system (see 4.4.7.1.4) is done when a second fault occurs. Typically only detection is done after the first fault in an IT *system*.

NOTE 4 Where *double insulation* or *reinforced insulation* is provided, a short circuit to earth would be considered to be two faults.

For *pluggable equipment type A*, the protective device is provided in the *installation* and shall not require any specific characteristics other than that required in IEC 60364 or other local *installation* codes.

For *pluggable equipment type B* or fixed installed equipment, this protection may be provided by devices external to the equipment, in which case the installation instructions shall state the need for the protection to be provided in the *installation* and shall include the specifications for the required short circuit and/or overload protection (see 6.3.7).

NOTE 5 IEC 60364 provides requirements for short circuit and overload protection of the input wiring in the *installation*. The above requirement ensures that the user is informed about any special characteristics of the protective devices for the protection of the **SMPS**, in addition to the requirements in IEC 60364 or other local *installation* codes.

If a protective device interrupts the neutral conductor, it shall also simultaneously interrupt all other supply conductors of the same circuit. It is permissible for the protective device to interrupt the neutral conductor after the other supply conductors of the same circuit.

Compliance shall be checked by inspection and where necessary, by simulation of *single fault conditions* (see 4.2) and by the tests of 5.2.4.4 and 5.2.4.5.

4.3.2 Specification of input short-circuit withstand strength and output short circuit current ability

4.3.2.1 General

The interrupting capability of the overcurrent protective device shall be equal or greater than the *prospective short circuit current* of the *mains supply*.

For *pluggable equipment type A*, either the **SMPS** shall be designed so that the building *installation* provides *short circuit backup protection*, or additional *short circuit backup protection* shall be provided as part of the equipment.

For *permanently connected equipment* or *pluggable equipment type B*, it is permitted for *short circuit backup protection* to be in the building *installation*.

4.3.2.2 Input ports short-circuit withstand strength

The input *prospective short circuit current* ratings apply to *ports* intended to be connected to battery circuits, external *mains supply*, *non-mains* a.c. or d.c. sources, and to other *ports* for which overcurrent protection is necessary.

For co-ordination and selection of internal or external protective devices, the **SMPS** manufacturer shall specify:

- a maximum allowable *prospective short circuit current* for each input *port* of the **SMPS**; and
- a minimum required *prospective short circuit current* in order to ensure proper operation of the protective device

NOTE 1 This requirement is especially applicable to fuses, which are not specified to be operated below a certain fault current value.

NOTE 2 The maximum allowable and minimum required *prospective short circuit current* are used to ensure a proper coordination between the *prospective short circuit current* and a *suitable protective device* at the location of the electrical *installation*.

If external protective devices are specified or provided the characteristics of those shall be specified by the manufacturer.

See 6.2 for marking.

4.3.2.3 Output short circuit current ability

The *output short circuit current* ratings apply to a.c. and d.c. power output *ports* and to other *ports* for which overcurrent protection is necessary.

For all output *ports*, short circuit evaluation to determine the minimum and maximum *output short circuit current* shall be performed according to 5.2.4.4 and the *output short circuit current* available from the **SMPS** shall be specified as in 5.2.4.4 and 6.2.

Internal electronic output short circuit protection is considered acceptable as an output short circuit protection device of the **SMPS**, when compliance is shown by test in 5.2.4.4.

4.3.2.4 Combined input and output ports

For *ports* which are both input and output *ports* the applicable requirements of both 4.3.2.1 and 4.3.2.3 apply.

4.3.3 Short-circuit coordination (backup protection)

Protective devices provided or specified shall have adequate breaking capability to interrupt the maximum *prospective short circuit current* specified for the *port* to which they are connected.

If internal protection of the *SMPS* is not rated for the *prospective short circuit current*, the installation instructions shall specify an upstream protective device, rated for this *prospective short circuit current* of that *port*, which shall be used to provide backup protection. Analysis shall ensure the protection coordination between the external and internal protective device.

NOTE IEC 60364 provides requirements for upstream protective devices of the backup protection in the *installation*. The above requirement ensures that the user is informed about any special characteristics of the upstream protective devices for the backup protection of the *SMPS*, in addition to the requirements in IEC 60364 or other local *installation* codes.

Compliance shall be checked by inspection and by the tests of 5.2.4.4 and 5.2.4.5.

4.3.4 Protection by several devices

Where protective devices that require manual replacement or resetting are used in more than one pole of a supply to a given load, those devices shall be located together. It is permitted to combine two or more protective devices in one component.

Compliance shall be checked by inspection.

4.4 Protection against electric shock

4.4.1 General

Protection against electric shock depends on the *decisive voltage class* from 0 and *insulation* requirements from 4.4.2.3, and is to be provided by at least one of the following measures:

- *basic protection* from 4.4.3 and *fault protection* from 4.4.4;
- *enhanced protection* from 4.4.5

Protection under normal conditions is provided by *basic protection*, and protection under *single fault conditions* is provided by *fault protection*.

Enhanced protection provides protection under both conditions.

Additional protection can be provided by residual current-operated protective devices (RCD). For further information, see 4.4.8.

NOTE In this standard, 4.4.1 to 4.4.6 have been harmonized with the concepts of the horizontal standard IEC 61140 for protection against electrical shock. *Basic protection*, *fault protection*, *enhanced protection* and the combination of those measures has been implemented.

4.4.2 Decisive voltage class

4.4.2.1 General

Replacement:

No access protection is required if under normal operation and under *single fault condition* the *DVC As* limits, derived from Table 5, are not exceeded in this document. Values of *DVC B* are not allowed to be touchable by the test finger, except for connectors of telecommunication circuits. *DVC C* is not allowed to be touched, and clearance requirements to the test finger do apply.

NOTE Refer to Table A.4, row 4 for examples on clearance requirements.

4.4.2.2 Determination of decisive voltage class

4.4.2.2.1 General

The provisions of clause 4.4.2.2.1 of IEC 62477-1:2012 do not apply.

NOTE The considerations related to **SMPS** regarding their application and environment lead to the conclusion to only use the DVC A voltage levels for dry hand and DVC A2 for water wet environments.

Addition:

4.4.2.2.1.100 Additional DVC considerations

The manufacturer defines the **DVC** for the individual output circuits and provides the information with the accompanying documentation.

Inputs/output circuits with rated voltages within the limits of **DVC As** are investigated as **DVC As** circuits, except they are differently specified by the manufacturer (see 6.2.101) and only intended to be accessed by a **service person**.

SELV and **PELV** circuits have to be **DVC** classified in order to apply the proper requirements. **DVC** circuits can be earthed or unearthed.

NOTE SELV and PELV circuits are covered as DVC As or DVC B depending on working voltage. The maximum DVC B voltage is limited to the ELV limits as defined in IEC 61140 (same as SELV and PELV) under normal and single fault condition and is used for example, as interface to SELV/PELV circuits.

For determination of transients of any other external circuit, 5.4.2.3.2.4 and Table 14 of the IEC 62368-1:2014 can be used.

4.4.2.2.1.101 DVC As levels for water wet locations

Accessible parts and **DVC As** outputs of **SMPS** designed for usage in water wet locations shall comply with reduced voltage levels as defined in Table 5.

4.4.2.2.2 Selection tables for contact area and skin humidity condition

The provisions of 4.4.2.2.2 of IEC 62477-1:2012 do not apply.

4.4.2.2.3 Limits of the working voltage for the DVC

Replacement:

The provisions of clause 4.4.2.2.3 of IEC 62477-1:2012 are replaced by:

Limits for the **working voltage** regarding the **DVC** for normal operation and during fault and abnormal operation are given in Table 5.

Table 5 of IEC 62477-1:2012 is replaced by Table 5 of this document.

Table 5 – Voltage limits

DVC	Limits of working voltage during normal operation V				Limits of working voltage during fault and abnormal conditions V	
	AC voltage (RMS) U_{AC}	AC voltage (peak) U_{peak}	DC voltage (mean) U_{DC}	Limit for overvoltage U_{peak}	Voltage (peak AC or DC) up to 200 ms ^{a,d}	Voltage (peak AC or DC) after 1 000 ms ^{a,d}
As	30/12 ^c	42,4/17 ^c	60/28 ^c	1 500 ^e	120	NOPL ^b
B	50	71	120	1 500 ^e		
C	all circuits not meeting DVC As or DVC B			N/A	N/A	

^a Linear interpolation is allowed between 200 ms and 1 000 ms.

^b Relevant normal operation limit (NOPL), as described in this table, corresponding to the appropriate voltage type.

^c Limits for water wet location applications.

^d Single pulses relate to DC voltage limits and repetitive pulses relate to AC voltage limits.

^e Maximum transients with the 1,2/50 μs impulse characteristic.

NOTE DVC A1 and A3 limits are not used.

For testing, see 5.2.4.

4.4.2.3 Requirements for protection against electric shock

Replacement:

The provisions of clause 4.4.2.3 of IEC 62477-1:2012 are replaced by:

User and service persons shall be protected against electric shock by the methods for **enhanced protection** outlined in 4.4.5.

The requirement of this document for protection against electric shock to be provided by Table 6 unless other insulation means are provided, in which case failure analysis and testing shall show that the requirements of 4.1 and 4.4 are met.

Table 6 – Separation requirements for circuit under consideration

Circuit under consideration ^e	To operator accessible parts and parts not reliably connected to PE ^a	To service accessible parts	To service accessible parts in RAL	To PE and conductive parts reliably connected to PE	DVC As	DVC B	DVC C
DVC As	None ^b	None ^b	None ^b	None ^b	None ^{b,c}	PS	PS
DVC B	SS ^d	SS	None ^b	None ^b		None ^{b,c}	PS
DVC C	PS ^d	PS	PS	SS			None ^{b,c}

NOTE This table describes the separation requirements between different galvanically separated circuits.

SS: Simple separation

PS: Protective separation

^a For example, functionally earthed.

^b Protection is not necessary for safety, but may be required for functional reasons according to 4.4.7.3. For DVC As circuits located in different environments, SS shall be used.

^c PS is needed, if a single insulation fault between circuits leads to a violation of the individual circuits DVC classification.

^d SS to tip of test finger and PS to enclosure contact point of test finger. See row 4 of Table A.4.

^e For water-wet environmental conditions, DVC As circuits for dry environment (higher limits of Table 5) and DVC B are to be read as DVC C circuits (in this table only) to determine the separation requirements.

NOTE Refer to Annex AD for further explanation.

4.4.3 Provision for basic protection

4.4.3.1 General

Replacement:

Basic protection is employed to establish a first level of protection to prevent persons from touching **hazardous-live-parts**.

It shall be provided by means of basic insulation of **live parts** in 4.4.3.2.

NOTE 1 Basic protection itself is considered insufficient for protection of users, as basic protection can be damaged or faulted.

NOTE 2 Refer to Annex AD for further explanation.

4.4.3.2 Protection by means of basic insulation of live parts

Replacement:

Basic insulation may be provided by solid insulation or air clearance.

The insulation shall be rated according to the impulse voltage, temporary overvoltage or working voltage (see 4.4.7.2.1), whichever gives the most severe requirement. It shall not be possible to remove the insulation without the use of a tool or key.

An accessible conductive part is considered to be conductive if its surface is bare or is covered by an insulating layer that does not comply with the requirements of at least basic insulation.

Basic insulation has to be provided as required by Table 6.

The basic insulation shall be designed and tested to withstand the impulse voltages and temporary overvoltages for the circuits to which they are connected. See 5.2.3.2 and 5.2.3.4 for tests.

Clause A.7 provides examples of the use of elements of protective measures.

4.4.3.3 Protection by means of enclosures or barriers

Replacement:

Refer to clause 4.4.5.100.

4.4.3.4 Protection by means of limitation of touch current and charge

Replacement:

Refer to clause 4.4.5.102 or 4.4.5.103 as relevant.

4.4.3.5 Protection by means of limited voltages

The provisions of clause 4.4.3.5 of IEC 62477-1:2012 do not apply.

NOTE Requirements regarding limited voltages are located in 4.4.5.101.

4.4.4 Provision for fault protection

4.4.4.1 General

Replacement:

Fault protection is employed to establish a second level of protection to prevent persons from touching ***hazardous-live-parts***. Fault protection requires basic protection first and shall be provided in addition by one or more of the following measures:

- a) protective equipotential bonding in 4.4.4.2 in combinations with the PE conductor in 4.4.4.3;
- b) automatic disconnection of supply in 4.4.4.4;
- c) ***supplementary insulation*** in 4.4.4.5;
- d) electrically protective screening in 4.4.4.7.

Addition:

4.4.4.1.100 Additional measures for protection

In addition to the measures outlined in 4.4.4.1, it can be necessary in an electrical circuitry to provide additional measures to prevent from a risk of electric shock resulting from ***single fault*** or ***abnormal operating condition*** as investigated according to 4.2.

These additional measures, consisting of components or insulation, shall be carefully selected to ensure operation over the product lifetime.

NOTE 1 An example would be voltages on the secondary side of an isolating transformer in a SMPS, which exceed the voltage limits of DVC As, but additional components in the secondary side ensure that the output voltage of the SMPS meets the limits of DVC As under normal and fault conditions.

NOTE 2 Functional safety according to IEC 61508 (all parts) or IEC 60730-1 can be used to achieve an acceptable level of safety by means of electronics (e.g. integrated circuits, ASICs, FPGAs) with or without software. However, this document does not provide any guidance on selection of an acceptable risk level. A SMPS can be also investigated according to this document by disabling or extensive simulation of faults on such safety means.

Two output circuits have to be separated by protective separation, if fault testing of combinations of circuits, according to 4.2, leads to an excess of the relevant circuit limits.

4.4.4.2 Protective equipotential bonding

4.4.4.2.1 General

Protective equipotential bonding shall be provided between accessible conductive parts of the equipment and the means of connection for the *PE conductor*, except:

- a) accessible conductive parts that are protected by one of the measures in 4.4.6.4; or
- b) when accessible conductive parts are separated from *live parts* using *double* or *reinforced insulation*.

Electrical contact to the means of connection of the *PE conductor* shall be achieved by one or more of the following means:

- through direct metallic contact;
- through other accessible conductive parts or other metallic components which are not removed when the *SMPS* is used as intended;
- through a dedicated *protective equipotential bonding* conductor.

When painted surfaces (in particular powder painted surfaces) are joined together, masking of paint, paint piercing methods or a separate connection shall be made to ensure reliable contact.

Where electrical equipment is mounted on lids, doors, or cover plates, continuity of the *protective equipotential bonding* circuit shall be ensured by a dedicated conductor or equivalent means complying with the requirements for *protective equipotential bonding*. If fasteners, hinges or sliding contacts do not provide and guarantee low enough impedance, sufficient parallel bonding is required.

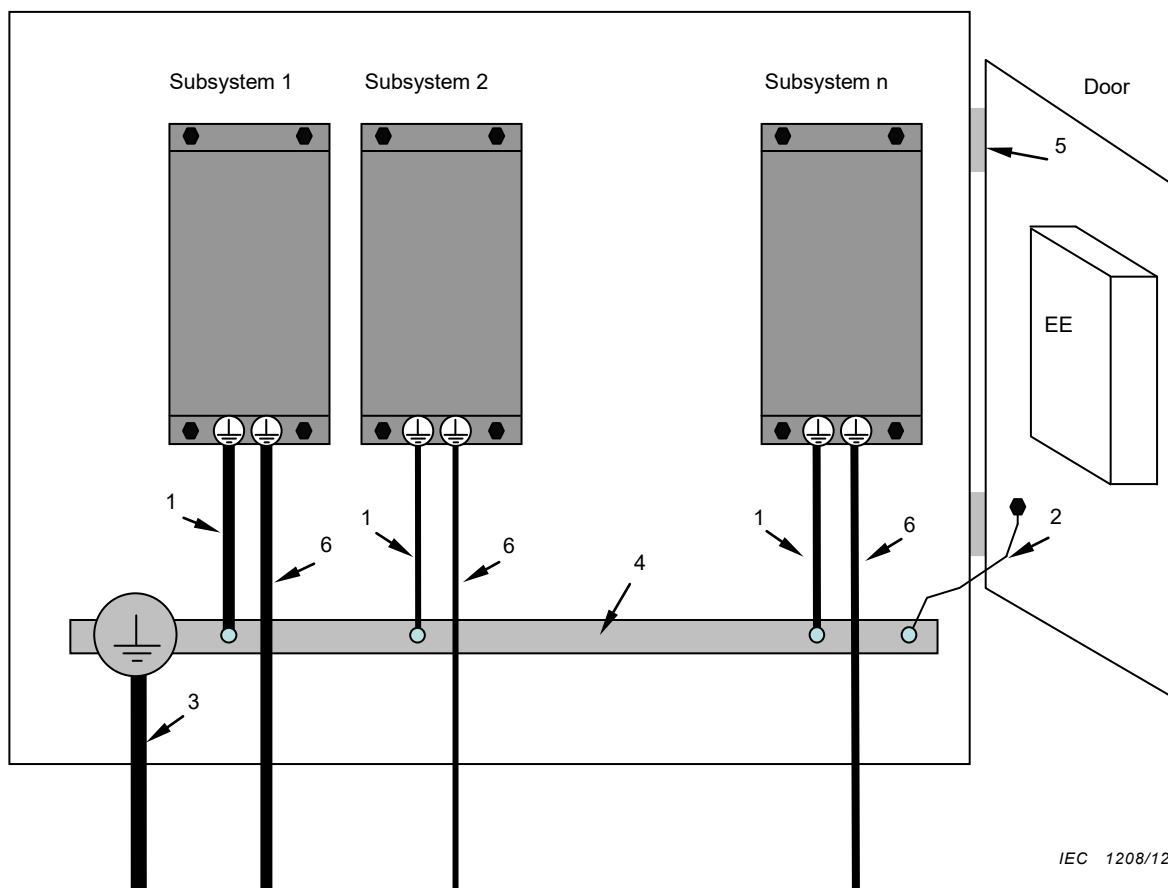
Electrical connections of *protective equipotential bonding* circuit shall be designed so that contact pressure is not transmitted through insulating material, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

Unless specified by the manufacturer and in compliance with 4.4.4.2.2 metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as *protective equipotential bonding* means. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (for example cable armouring, lead sheath) shall be connected to the *protective equipotential bonding* circuit.

The *protective equipotential bonding* circuit shall not incorporate a component such as switch or overcurrent protective devices which may open the circuit.

The electrical connection points of the *protective equipotential bonding* shall be corrosion-resistant.

Figure 4 shows an example of a *SMPS* assembly and its associated *protective equipotential bonding*.

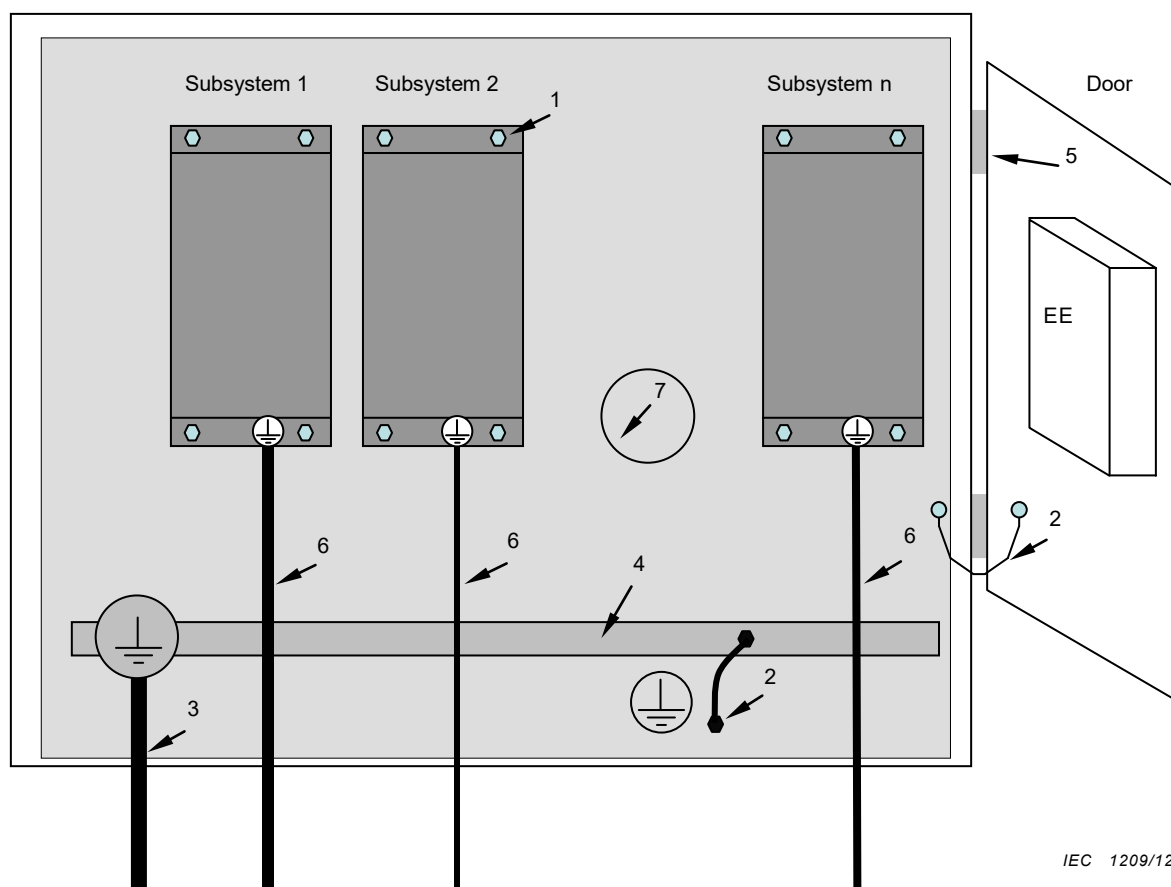


Key

- 1 *protective equipotential bonding of subsystems or SMPS PE conductor (dimensioned according to SMPS requirements)*
- 2 *protective equipotential bonding*
- 3 *PE conductor (dimensioned according to SMPS requirements) to installation earthing point*
- 4 *earth bar*
- 5 *hinge*
- 6 *PE conductor to the load*
- EE *other electrical equipment (bonded as relevant for that equipment)*

Figure 4 – Example of a SMPS assembly and its associated protective equipotential bonding

Figure 5 shows an example of a SMPS assembly and its associated *protective equipotential bonding* through direct metallic contact.



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Key

- 1 *protective equipotential bonding of subsystems through direct metallic contact (paint removed)*
- 2 *protective equipotential bonding*
- 3 *PE conductor (dimensioned according to SMPS requirements) to installation earthing point*
- 4 *earth bar*
- 5 *hinge*
- 6 *PE conductor to the load*
- 7 *metal subplate*
- EE *other electrical equipment (bonded as relevant for that equipment)*

Figure 5 – Example of a SMPS assembly and its associated protective equipotential bonding

4.4.4.2.2 Rating of protective equipotential bonding

Protective equipotential bonding shall either be:

- a) *sized in accordance with the requirements for the PE conductor in 4.4.4.3 and the means of connection for the PE conductor in 4.4.4.3.2 to ensure no voltage drop exceeding the values from 4.4.2.2.3 during a fault; or*
- b) *sized*
 - *to withstand the highest stresses that can occur to the SMPS item(s) concerned when they are subjected to a fault connecting to accessible conductive parts; and*
 - *to remain effective for as long as a fault to the accessible conductive parts persists or until an upstream protective device removes power from the part; and*
 - *to ensure no voltage drop exceeding the values from 4.4.2.2.3 during normal operation and during a fault.*

Compliance shall be checked with the *type tests* in 5.2.3.11.

4.4.4.3 PE conductor

4.4.4.3.1 General

A *PE conductor* shall be connected at all times when power is supplied to the *SMPS*, unless the *SMPS* complies with the requirements of *protective class II* (see 4.4.6.3) or *protective class III*. Unless local wiring regulations state otherwise, the *PE conductor* cross-sectional area shall be determined from Table 7 or by calculation according to 543.1 of IEC 60364-5-54:2011.

If the *PE conductor* is routed through a plug and socket, or similar means of disconnection, it shall not be possible to disconnect it unless power is simultaneously removed from the part to be protected.

Table 7 – *PE conductor* cross-section^a

Cross-sectional area of phase conductors of the <i>SMPS</i> S mm ²	Minimum cross-sectional area of the corresponding <i>PE conductor</i> S_p mm ²
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S$	$S/2$
^a These values are valid only if the <i>PE conductor</i> is made of the same material as the phase conductors. In case of different materials the cross-sectional area of the <i>PE conductor</i> shall be determined in a manner which produces a conductance equivalent to that which results from the application of this table.	

The cross-sectional area of every *PE conductor* that does not form part of the supply cable or cable *enclosure* shall, in any case, be not less than:

- 2,5 mm² if mechanical protection is provided; or
- 4 mm² if mechanical protection is not provided.

Provisions within cord-connected equipment shall be made so that the *PE conductor* in the cord shall, in the case of failure of the strain-relief mechanism, be the last conductor to be interrupted.

For special *system* topologies, the *SMPS* designer shall verify the *PE conductor* cross-section required.

4.4.4.3.2 Means of connection for the PE conductor

SMPS shall have a means of connection for the *PE conductor*, located near the terminals for the respective live conductors. The means of connection shall be corrosion-resistant and shall be suitable for the connection of conductors according to Table 7 and of cables in accordance with the wiring rules applicable at the *installation*. The means of connection for the *PE conductor* shall not be used as a part of the mechanical assembly of the equipment or for other connections. Connection and bonding points shall be designed so that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences.

Where enclosures and/or conductors of aluminium or aluminium alloys are used, particular attention should be given to the problems of electrolytic corrosion.

Compliance shall be checked by inspection.

Annex K provides further information about electrochemical corrosion.

See 6.3.7.3.2 for marking requirements.

The marking shall not be placed on or fixed by screws, washers or other parts which might be removed when conductors are being connected.

4.4.4.3.3 Requirements for reliable earthing

NOTE The header of this subclause has been changed for easier understanding.

The requirements of this subclause shall be satisfied to prevent accessible conductive parts to become dangerous in case of damage to or disconnection of the *PE conductor*.

For *pluggable type A* equipment, the *touch current* shall not exceed the limits specified in 4.4.3.4.

For all other *SMPS*, one or more of the following measures shall be applied, unless the *touch current* can be shown to be less than the limits specified in 4.4.3.4:

a) Use of a fixed connection and

- a cross-section of the *PE conductor* of at least 10 mm² Cu or 16 mm² Al; or
- automatic disconnection of the supply in case of discontinuity of the *PE conductor*; or
- provision of an additional terminal for a second *PE conductor* of the same cross-sectional area as the original *PE conductor*;

or

b) Use of a *pluggable type B* connection with a minimum *PE conductor* cross-section of 2,5 mm² as part of a multi-conductor power cable. Adequate strain relief shall be provided.

For marking requirements, see 6.3.7.4.

Compliance is checked by inspection and by test of 5.2.3.7.

For equipment which may be energized from multiple sources of supply, the *touch current* limits above apply in all possible intended *installation* configurations and combinations of sources that may be energized at the same time, unless one of the measures in a) or b) above is used.

When it is intended and allowed to interconnect two or more *SMPS* using one common *PE conductor*, the above *touch current* requirements apply to the maximum number of *SMPS* to be interconnected, unless one of the measures in a) or b) above is used. The maximum number of interconnected *SMPS* is used in the testing and has to be stated in the installation manual.

4.4.4.4 Automatic disconnection of supply

For automatic disconnection of supply:

- a *protective equipotential bonding system* shall be provided; and
- a protective device operated by the fault current shall disconnect one or more of the line conductors supplying the equipment, *system* or *installation*, in case of a failure of *basic insulation*.

The protective device shall interrupt the fault current within a time as specified in Figure 1, Figure 2 or Figure 3 in 4.4.2.2.3 of 62477-1:2012.

4.4.4.5 Supplementary insulation

Supplementary insulation is an independent *insulation* applied in addition to *basic insulation* for *fault protection* and shall be dimensioned to withstand the same stresses as specified for *basic insulation*.

Addition:

4.4.4.5.100 Provision of supplementary insulation

Supplementary insulation has to be provided as required by Table 6.

4.4.4.6 Simple separation between circuits

Simple separation between a circuit and other circuits or earth shall be achieved by *basic insulation* throughout, rated for the highest voltage present.

If any component is connected between the separated circuits, that component shall withstand the electric stresses specified for the insulation which it bridges.

If any component is connected between a circuit and a circuit connected to earth, its impedance shall limit the current flow through the component to the steady-state *touch current* values indicated in 4.4.3.4.

4.4.4.7 Electrically protective screening

Electrically protective screening interposed between *hazardous live parts* of a *SMPS*, shall consist of a conductive screen connected to the *protective equipotential bonding* of the *SMPS* whereby the screen is separated from *live parts* by at least *simple separation*.

The protective screen and the connection to the *protective equipotential bonding system* of the *SMPS* and that interconnection shall comply with the requirements of 4.4.4.2.

4.4.5 Enhanced protection

4.4.5.1 General

Replacement:

The provisions of 4.4.5.1 of IEC 62477-1:2012 are replaced by:

Enhanced protection is generally acceptable to protect the user or service person. It consists of two levels of protection, or one reinforced level of protection considered equivalent to two levels of protection, to prevent persons from touching ***hazardous-live-parts***.

Enhanced protection is achieved by:

- protection by prevention of access, as described in 4.4.5.100; or
- protection by protective separation between circuits in 4.4.5.3, together with at least one of the following measures for:
 - a) limitation of voltage, as described in 4.4.5.101;
 - b) limitation of current, as described in 4.4.5.102;
 - c) limitation of energy or charge, as described in 4.4.5.103;
 - d) protective impedance, as described in 4.4.5.4.

Additional protection as described in 4.4.4.1.100 might be necessary to comply with these measures.

NOTE Refer to Annex AD for further explanation.

4.4.5.2 Reinforced insulation

Reinforced insulation shall be so designed as to be able to withstand electric, thermal, mechanical and environmental stresses with the same reliability of protection as provided by *double insulation* (*basic insulation* and *supplementary insulation*, see 4.4.3.2 and 4.4.4.5).

4.4.5.3 Protective separation between circuits

Protective separation between a circuit and other circuits shall be achieved by one of the following means:

- *double insulation* (*basic insulation* and *supplementary insulation* in 4.4.3.2 and 4.4.4.5);
- *reinforced insulation* in 4.4.5.2;
- *electrically protective screening* in 4.4.4.7;
- a combination of these provisions.

If conductors of the separated circuit are contained together with conductors of other circuits in a multi-conductor cable or in another grouping of conductors, they shall be insulated, individually or collectively, for the highest voltage present, so that *double insulation* is achieved.

If any component is connected between the separated circuits, that component shall comply with the requirements for *protective impedance* devices (see 4.4.5.4)

4.4.5.4 Protection by means of protective impedance

Protective impedance shall be arranged so that under both normal and *single fault conditions* the current and discharge energy available shall be limited according to 4.4.3.4.

The *protective impedances* shall be designed and tested to withstand the impulse voltages and *temporary overvoltages* for the circuits to which they are connected. See 5.2.3.2 and 5.2.3.4 for tests.

Compliance with the requirement for the limitation of *touch current* is checked by test of 5.2.3.6.

Compliance with the requirement for the discharge energy shall be checked by performing calculations and/or measurements to determine the voltage and capacitance.

NOTE A *protective impedance* designed according to this subclause is not considered to be a galvanic connection.

Addition:

4.4.5.100 Protection by prevention of access

Operator access to parts or circuits other than **DVC As** shall be:

- arranged in **enclosures** or located behind **enclosures** or barriers, which meet at least the requirements of the protective type IPXXB according to Clause 7 of IEC 60529:1989;
- located under top surfaces of enclosures or barriers which are accessible when the equipment is energized fulfilling the test with the IP3X test probe of 5.2.2.2.

For **moveable equipment** with no defined top and bottom the test with the IP3X test probe of 5.2.2.2 applies to all sides.

If the **SMPS** is installed in a **restricted access area**, IPXXB instead of the test with the IP3X test probe of 5.2.2.2 applies.

Compliance is shown by test of 5.2.2.2.

It shall only be possible to open **enclosures** or remove barriers:

- with the use of a tool or key; or
- after de-energization of parts or circuits other than **DVC As**.

Where the **enclosure** is required to be opened and the **SMPS** energized during installation or maintenance:

- a) parts or circuits other than **DVC As** shall be protected by at least IPXXA; and
- b) parts or circuits other than **DVC As** that are likely to be touched when making adjustments shall be protected by at least IPXXB; and
- c) it shall be ensured that persons are aware that parts or circuits other than **DVC As** are accessible.

Protection of a **service person** in **restricted access areas** can be alternatively achieved by:

- a) means of **basic insulation** of **live parts** in 4.4.3.2 or below methods of b) and c);
- b) prevention of contact parts or circuits other than **DVC As** or **DVC B** and
- c) prevention of unintentional contact by usage of warning markings for non-obvious hazards (e.g. discharge of capacitors).

For marking requirements, see 6.3.7.1.

Enclosures of **protective class I** products have to meet 4.4.6.2 and **enclosures** of **protective class II** products have to meet 4.4.6.3.

4.4.5.101 Protection by limitation of voltage

Operator access is only allowed to parts/circuitry or simultaneously accessible parts/circuitry of **DVC As** except for connectors with **DVC B** for telecommunication circuits (see 4.4.2.1). Within this document a **DVC As** represents a safe to touch circuit, as it has to meet:

- a) protective separation requirements as outlined in 4.4.5; and
- b) voltage limits according to Table 5, during normal and fault conditions, with considerations according to 4.2 and testing to 5.2.4.

Service person access is allowed to parts/circuitry or simultaneously accessible parts/circuitry up to voltages at **DVC B**.

The **DVC B** circuit has to meet:

- a) protective separation requirements as outlined in 4.4.5; and
- b) voltage limits according to 4.4.2.2.3 Table 5, during normal and fault conditions, with considerations according to 4.2 and testing to 5.2.4.

4.4.5.102 Protection by limitation of current

Access to parts able to deliver currents over the limits of Table 100 shall be prevented under normal, fault and abnormal operation, except for conductive parts reliably connected to PE according to 4.4.4.3.3, if they are marked as described in 6.3.7.4.

Table 100 – Limits for access of current

Frequency range	Normal operation limit ^{a,b}	Fault condition limit ^{a,b}
Direct current	2 mA	10 mA
Up to 1 kHz	0,5 mA RMS or 0,7 mA peak	3,5 mA RMS or 5 mA peak
1 kHz up to 100 kHz	0,5 mA RMS. x frequency in kHz or 0,7 mA peak. x frequency in kHz	3,5 mA RMS + 0,95 x frequency in kHz or 5 mA peak + 0,95 x frequency in kHz
Above 100 kHz	50 mA RMS or 70 mA peak	100 mA RMS or 140 mA peak
^a For non-sinusoidal waveforms, the peak values apply and the current is measured using the measuring network specified in Figure 4 of IEC 60990:1999, for currents up to 2 mA, or Figure 5 of IEC 60990:1999, for currents above. ^b For sinusoidal waveforms and DC, the RMS values apply and the current may be measured using a 2 000 Ω resistor.		

The currents are measured according to 5.2.3.7 and 5.2.3.7.100.

When protective impedances are used to bridge any insulation 4.4.5.4 and 4.4.7.1.7 applies.

4.4.5.103 Protection by limitation of energy or charge

The limitation of energy or charge has to be investigated in unloaded condition.

Operator access to parts at an energy above 0,5 mJ shall be prevented under normal and under fault and abnormal operation. Additionally, the requirements for capacitor discharge of 4.4.9 and access with test finger to hazardous energy level of 4.5.1.1 apply.

NOTE 1 Voltage limits at a certain capacitance can be calculated over the formula $U = \sqrt{\frac{E}{C}}$.

Service persons shall not have access to a stored charge above 50 µC, with the exception that there is no energy limit in **restricted access areas**, if the preventions of 4.4.5.100 are used.

NOTE 2 Voltage limits at a certain capacitance can be calculated over the formula $U = \frac{Q}{C}$.

4.4.6 Protective measures

4.4.6.1 General

NOTE Refer to Annex AD for further explanation.

That part of a **SMPS** which meets the requirements of 4.4.6.2 is defined as *protective class I*.

That part of a **SMPS** which meets the requirements of 4.4.6.3 is defined as *protective class II*.

That part of a **SMPS** which meets the requirements of 4.4.6.4 is defined as *protective class III*.

Compliance shall be checked by satisfying the requirements for *protective class I*, *class II* or *class III*.

A.7 provides Examples of the use of elements of protective measures.

Equipment of protective *class I*, *II* and *III* shall be marked according to 6.3.7.3.

4.4.6.2 Protective measures for protective class I equipment

Protective class I equipment shall meet the requirements for:

- *basic protection* in 4.4.3; and
- *fault protection* in 4.4.4.2 and 4.4.4.3 with respect to equipotential bonding and *PE conductor*.

4.4.6.3 Protective measures for protective class II equipment

Replacement:

Protective class II equipment shall meet the requirements for enhanced protection according to 4.4.5.

Protective class II equipment shall not have means of connection for the PE conductor. This does not apply if a PE conductor is passed through the equipment to equipment series connected beyond it.

In the latter case, the PE conductor and its means for connection shall be separated from

- accessible surface of the equipment, and
- circuits which employ protective separation

with at least basic insulation designed according to the rated voltage of the series-connected equipment.

Equipment of protective class II may have provision for the connection of an earthing conductor for functional reasons or for the damping of overvoltages. In this case, the functional earthing conductor shall meet the same separation requirements like a **DVC As** circuit.

Equipment of protective class II shall be marked according to 6.3.7.3.3.

Compliance is checked by inspection.

4.4.6.4 Protective measures for protective class III equipment or circuits

4.4.6.4.1 General

Protective measures shall be achieved by protective separation by one of the following means:

- *basic insulation and supplementary insulation (double insulation)* according to 4.4.3.2 and 4.4.4.5;
- *reinforced insulation* according to 4.4.5.2;
- *electrically protective screening and simple separation* according to 4.4.4.7; or
- a combination of these provisions;

used in combination with one of the following means:

- *protective impedance* according to 4.4.5.4 comprising limitation of discharge energy and of current; or
- limitation of voltage according to 4.4.3.5.

The *protective separation* shall be fully and effectively maintained under all conditions of intended use of the **SMPS**.