IEC 61140

Edition 4.0 2016-01
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

BASIC SAFETY PUBLICATION

Protection against electric shock – Common aspects for installations and equipment

IEC 61140:2016-01 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.260; 29.020; 91.140.50

ISBN 978-2-8322-3132-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATION AND EQUIPMENT

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61140 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition cancels and replaces the third edition published in 2001 and Amendment 1:2004. This edition constitutes a technical revision.

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

a) Introduction of the content of IEC 60449
b) Better distinction between provisions and measures
c) Consideration of effects other than ventricular fibrillation
d) Additional protection was introduced
e) ELV defined as part of LV
f) Devices suitable for isolation required for automatic disconnection of supply (LV)
g) Requirements relating to current in the protective conductor were moved to the main body of the standard

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

FDIS	Report on voting
64/2076/FDIS	64/2091/RVD

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

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

It has the status of a basic safety publication in accordance with IEC Guide 104.

The reader's attention is drawn to the fact that Annex C lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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

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

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~~INTRODUCTION~~

PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATIONS AND EQUIPMENT

1 Scope

This International Standard is a basic safety publication primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

It is not intended to be used as a stand-alone standard.

According to IEC Guide 104, technical committees, when preparing, amending, or revising their publications, are required to make use of any basic safety publication such as IEC 61140.

This International Standard applies to the protection of persons and ~~animals~~ livestock against electric shock. The intent is to give fundamental principles and requirements which are common to electrical installations, systems and equipment or necessary for their coordination, without limitations with regard to the magnitude of the voltage or current, or the type of current, and for frequencies up to 1 000 Hz.

~~This standard has been prepared for installations, systems and equipment without a voltage limit.~~

~~NOTE~~ Some clauses in this standard refer to low-voltage and high-voltage systems, installations and equipment. For the purposes of this standard, low-voltage is any rated voltage up to and including 1 000 V a.c. or 1 500 V d.c.. High voltage is any rated voltage exceeding 1 000 V a.c. or 1 500 V d.c..

~~The requirements of this standard apply only if they are incorporated, or are referred to, in the relevant standards. It is not intended to be used as a stand-alone standard.~~

It should be noted that, for an efficient design and selection of protective measures, the type of voltage that may occur and its waveform needs to be considered, i.e. a.c. or d.c. voltage, sinusoidal, transient, phase controlled, superimposed d.c., as well as a possible mixture of these forms. The installations or equipment may influence the waveform of the voltage, e.g. by inverters or converters. The currents flowing under normal operating conditions and under fault conditions depend on the described voltage.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60050(131): *International Electrotechnical Vocabulary (IEV) – Chapter 131: Electric and magnetic circuits*~~

~~IEC 60050(195): 1998, *International Electrotechnical Vocabulary (IEV) – Part 195: Earthing and protection against electric shock*~~
~~Amendment 1 (2001)~~

~~IEC 60050(351):1998, *International Electrotechnical Vocabulary – Part 351: Automatic control*~~

~~IEC 60050(826):1982, *International Electrotechnical Vocabulary – Chapter 826: Electrical installations of buildings*~~
~~Amendment 2 (1995)~~

IEC 60038, *IEC standard voltages*

IEC 60068 (all parts), *Environmental testing*

IEC 60071-1~~:1993~~, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60071-2~~:1996~~, *Insulation coordination – Part 2: Application guide*

~~IEC 60364-4-41, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock*~~

~~IEC 60364-4-443:1995, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 44: Protection against overvoltages – Section 443: Protection against overvoltages of atmospheric origin or due to switching*~~

IEC 60364-5-54:~~1980~~ 2011, *Low-voltage electrical installations ~~of buildings~~ – Part 5-54: Selection and erection of electrical equipment – ~~Chapter 54:~~ Earthing arrangements and protective conductors*

~~IEC 60364-6-61:1986, *Electrical installations of buildings – Part 6: Verification – Chapter 61: Initial verification*~~

IEC 60417, *Graphical symbols for use on equipment*
(available at http://www.graphical-symbols.info/equipment)

~~IEC 60417-2, *Graphical symbols for use on equipment – Part 2: Symbol originals*~~

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

~~IEC 60446:1999, *Basic and safety principles for man-machine interface, marking and identification – Identification of conductors by colours or numerals*~~

IEC TS 60479-1:~~1994~~ 2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TR 60479-5, *Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects*

IEC 60529~~:1989~~, *Degrees of protection provided by enclosure~~s~~ (IP Code)*

~~IEC 60601 (all parts), *Medical electrical equipment*~~

~~IEC 60601-1:1988, *Medical electrical equipment – Part 1: General requirements for safety*~~

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

IEC 60664-1:~~1992~~ 2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60721 (all parts), *Classification of environmental conditions*

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

IEC TS 61201:~~1992~~ 2007, ~~*Extra-low-voltage (ELV) – Limit values*~~ *Use of conventional touch voltage limits – Application guide*

IEC 62271-102, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC Guide 104~~:1997~~, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51:~~1999~~ 2014, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

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

NOTE An index of definitions is given in Annex B.

3.1
electric shock
physiological effect resulting from an electric current through a human ~~or animal~~ body or livestock

Note 1 to entry: Physiological effects include, for example, perception, muscular contractions and tetany, difficulty in breathing, disturbances of heart function, immobilization, cardiac arrest, breathing arrest, burns or other cellular damage.

Note 2 to entry: Physiological effects resulting from EMF are not considered in this standard.

[SOURCE: IEC 60050-195:1998, 195-01-04, modified – "through a human body or livestock" replaces "passing through a human or animal body"; addition of 2 Notes to entry]

3.1.1
basic protection
protection against electric shock under fault-free conditions

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

~~NOTE For low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact as used in IEC 60364-4-41.~~

3.1.2
fault protection
protection against electric shock under single fault conditions

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-02]

~~NOTE For low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact as used in IEC 60364-4-41.~~

3.1.3
additional protection
protection against electric shock in addition to basic protection and/or fault protection

[SOURCE:IEC 60050-826:2004, 826-12-07, modified – "protection against electric shock" replaces "protective measure"]

3.1.4
single fault condition
condition in which one means for protection against electric shock is defective or one fault is present which could cause a hazard

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

3.2
~~(~~electric~~)~~ circuit
arrangement of devices or media through which electric current can flow

~~[IEV 131-01-01]~~

Note 1 to entry: See also IEC 60050-826:2004, ~~826-05-01~~ 826-14-01 for electrical installations of buildings.

3.3
~~(~~electrical~~)~~ equipment
item used for such purposes as generation, conversion, transmission, ~~storage,~~ distribution or utilization of electric energy, such as electric machines, transformers, ~~apparatus,~~ switchgear and controlgear, measuring instruments, protective devices, ~~accessories for wiring systems, appliances~~ wiring systems, current-using equipment

[SOURCE: IEC 60050-826:2004, ~~826-07-01, modified~~ 826-16-01]

3.4
live part
~~conductor or~~ conductive part intended to be energized in normal ~~operation~~ 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 concept does not necessarily imply a risk of electric shock.

~~NOTE 2 For definitions of PEM and PEL see IEV 195-02-13 and 195-02-14.~~

[SOURCE: IEC 60050-195:1998, 195-02-19, modified – "…normal conditions, including a neutral conductor or mid-point conductor" replaces "normal operation, including a neutral conductor.."]

3.5
hazardous-live-part
live part which, under certain conditions, can give a harmful electric shock

Note 1 to entry: In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case the surface is considered to be a hazardous-live-part.

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

3.6
exposed-conductive-part
conductive part of equipment, 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 electrical equipment which can become live only 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]

3.7
extraneous-conductive-part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-195:1998, 195-06-11]

3.8
touch voltage

3.8.1
(effective) touch voltage
voltage between conductive parts when touched simultaneously by a ~~person or an animal~~ human or livestock

Note 1 to entry: The value of the effective touch voltage may be appreciably influenced by the impedance of the person or the ~~animal~~ livestock in electric contact with these conductive parts.

[SOURCE: IEC 60050-195:1998, 195-05-11, modified – "by a human or livestock" replaces "by a person or an animal"]

3.8.2
prospective touch voltage
voltage between simultaneously accessible conductive parts when those conductive parts are not being touched, by a ~~person or an animal~~ human or livestock

[SOURCE: IEC 60050-195:1998, 195-05-09, modified – "by a human or livestock" replaces "by a person or an animal"]

3.9
touch current
electric current passing through a human body or through ~~an animal body~~ livestock when it touches one or more accessible parts of an installation or of equipment

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-05-21, modified – "through livestock" replaces "through an animal body"]

3.10
insulation
set of properties which characterize the ability of an insulation to provide its function

Note 1 to entry: Examples of relevant properties are: resistance, breakdown voltage.

Note 2 to entry: Insulation can be a solid, a liquid or a gas (e.g. air), or any combination.

[SOURCE: IEC 60050-151:2001, 151-15-42, modified – Note 2 to entry added]

3.10.1
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 60050-195:1998, 195-06-06]

3.10.2
supplementary insulation
independent insulation applied in addition to basic insulation, for fault protection

[SOURCE: IEC 60050-195:1998, 195-06-07]

3.10.3
double insulation
insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.10.4
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.

[SOURCE: IEC 60050-195:1998, 195-06-09, modified – ..provides “a degree” of ..., deleted]

3.11
non-conducting environment
provision whereby a ~~person or an animal~~ human or livestock touching an exposed-conductive-part that has become hazardous-live is protected by the high impedance of his environment (e.g. insulating walls and floors) and by the absence of earthed conductive parts

[SOURCE: IEC 60050-195:1998, 195-06-21, modified – “animal” replaced by “livestock”]

3.12
(electrically) protective obstacle
part preventing unintentional ~~direct~~ contact by a human or livestock with a live part, but not preventing ~~direct~~ such contact by deliberate action

[SOURCE: IEC 60050-195:1998, 195-06-16, modified – "direct contact" replaced by "contact" and ”by a human or livestock with a live part”.. introduced]

~~NOTE Direct contact is defined in IEV 195-06-03.~~

3.13
(electrically) protective barrier
part providing protection against ~~direct~~ contact by a human or livestock with a live part from any usual direction of access

[SOURCE: IEC 60050-195:1998, 195-06-15, modified – "direct contact" replaced by "contact" and “by a human or livestock with a live part” ... introduced]

~~NOTE Direct contact is defined in IEV 195-06-03.~~

3.14
(electrically) protective enclosure
electrical enclosure surrounding internal parts of equipment to prevent access to ~~hazardous~~ a live-part from any direction

Note 1 to entry: In addition, an enclosure generally provides protection against internal or external influences, e.g. ingress of dust or water or prevention of mechanical damage.

[SOURCE: IEC 60050-195:1998, 195-06-14, modified – "hazardous live-parts" replaced by "a live-part" and Note 1 to entry added]

3.15
arm's reach
zone of accessibility to touch extending from any point on a surface where persons usually stand or move about to the limits which a person can reach with the hand, in any direction, without assistance

[SOURCE: IEC 60050-195:1998, 195-06-12]

3.16
equipotential bonding
provision of electric connections between conductive parts intended to achieve equipotentiality

Note 1 to entry: The effectiveness of the equipotential bonding may depend on the frequency of the current in the bonding.

[SOURCE: IEC 60050-195:1998, 195-01-10, modified – Note 1 to entry added]

3.16.1
protective-equipotential-bonding
equipotential bonding for the purposes of safety (e.g. protection against electric shock)

Note 1 to entry: Functional equipotential bonding is defined in IEC 60050-195:1998, 195-01-16.

[SOURCE: IEC 60050-195:1998, 195-01-15, modified – "(e.g. protection against electric shock)" introduced and Note 1 to entry added]

3.16.2
equipotential bonding terminal
terminal provided on equipment or on a device and intended for the electric connection with the equipotential bonding system

[SOURCE: IEC 60050-195:1998, 195-02-32]

3.16.3
protective bonding terminal
terminal intended for protective-equipotential-bonding purposes

3.16.4
protective conductor~~, PE~~
conductor provided for purposes of safety, for example protection against electric shock

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.16.5
PE conductor
protective conductor provided for protective earthing

[SOURCE: IEC 60050-195:1998, 195-02-11, modified – term title changed]

3.16.6
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

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

3.16.7
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]

3.16.8
PEL conductor
conductor combining the functions of both a protective earthing conductor and a line conductor

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

3.16.9
protective bonding conductor
protective conductor provided for protective-equipotential-bonding

[SOURCE: IEC 60050-195:1998, 195-02-10]

3.16.10
line conductor
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]

3.16.11
neutral conductor
conductor electrically connected to the neutral point and capable of contributing to the distribution of electric energy

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

3.17
earth
~~NOTE The~~ Concept ~~"Earth" means~~ embracing the planet and all its physical matter

3.17.1
earth (verb)
ground (verb) (US)
to make an electrical connection between local earth and a given point in a system, installation or equipment

Note 1 to entry: The connection to local earth may be:

– intentional; or
– unintentional; or
– accidental

and may be permanent or temporary.

3.17.2
reference earth
reference ground (US)
part of the Earth considered as conductive, the electric potential of which is conventionally taken as zero, being outside the zone of influence of any earthing arrangement

[SOURCE: IEC 60050-195:1998, 195-01-01, modified – Note deleted]

3.17.3
(local) earth
(local) ground (US)
part of the Earth which is in electric contact with an earth electrode and the electric potential of which is not necessarily equal to zero

[SOURCE: IEC 60050-195:1998, 195-01-03]

3.17.4
earth electrode
ground electrode (US)
conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with the Earth

[SOURCE: IEC 60050-195:1998, 195-02-01]

3.17.5
earthing conductor
grounding conductor (US)
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

[SOURCE: IEC 60050-195:1998, 195-02-03]

3.17.6
earthing arrangement
grounding arrangement (US)
all the electric connections and devices involved in the earthing of a system, an installation and equipment

Note 1 to entry: This could be a locally limited arrangement of interconnected earth electrodes on the high-voltage side.

[SOURCE: IEC 60050-195:1998, 195-02-20, modified – Note 1 to entry added]

3.17.7
protective earthing
protective grounding (US)
earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11]

3.17.8
functional earthing
functional grounding (US)
earthing a point or points in a system or in an installation or in equipment for purposes other than electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.18
automatic disconnection of supply
interruption of one or more of the line conductors effected by the automatic operation of a protective device in the event of a fault

Note 1 to entry: This does not necessarily mean an interruption in all conductors of the supply system.

[SOURCE: IEC 60050-195:1998, 195-04-10, modified – "in the event of a fault" replaces "in case of a fault" and Note 1 to entry added]

3.19
enhanced protective provision
protective provision having a reliability of protection not less than that provided by two independent protective provisions

3.20
(conductive) screen
(conductive) shield (US)
conductive part that encloses or separates electric circuits and/or conductors

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-02-38]

3.21
(electrically) protective screen
(electrically) protective shield (US)
conductive screen (shield) used to separate an electric circuit and/or conductors from hazardous-live-parts

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-17]

3.22
(electrically) protective screening
(electrically) protective shielding (US)
separation of electric circuits or conductors from hazardous-live-parts by an electrically protective screen ~~(shield)~~ connected to the protective-equipotential-bonding system and intended to provide protection against electric shock

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-18]

3.23
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]

3.24
(electrically) protective separation
separation of one electric circuit from another by means of:

– double insulation; or
– basic insulation and electrically protective screening (shielding); or
– reinforced insulation

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-19]

3.25
(electrical) separation
protective measure in which ~~a circuit that is~~ hazardous-live-parts ~~is~~ are insulated from all other electric circuits and parts, from local earth and from touch

[SOURCE: IEC 60050-826:2004, 826-12-27]

3.26
extra-low voltage
~~(~~ELV~~)~~
~~any voltage not exceeding the relevant voltage limit specified in IEC 61201~~
voltage not exceeding the maximum value of the prospective touch voltage which is permitted to be maintained indefinitely under specified conditions of external influences

3.26.1
SELV system
electric~~al~~ system in which the voltage cannot exceed ~~ELV~~ the value of extra-low voltage:

– 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.

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

3.26.2
PELV system
electric~~al~~ system in which the voltage cannot exceed ~~ELV~~ 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]

3.27
protection by limitation of steady-state touch current and electric charge
protection against electric shock by electric circuit or equipment design so that under normal and fault conditions the steady-state ~~touch~~ current and electric charge are limited to below a ~~non-~~hazardous level~~s~~

[SOURCE: IEC 60050-826:2004, 826-12-34, modified – "steady-state current" replaced by "steady-state touch current"]

3.28
limited-current-source
device supplying electrical energy in an electric circuit

– with protective-separation from hazardous-live-parts, and
– which ensures that the steady-state touch current and charge are limited to non-hazardous levels, under normal and fault conditions

3.29
protective impedance device
component or assembly of components ~~the~~ whose impedance and construction ~~of which are such as to ensure that~~ limit steady-state-touch current and electric charge ~~are limited~~ to non-hazardous levels

[SOURCE: IEC 60050-826:2004, 826-12-35, modified – “are intended to” limit … deleted]

3.30
(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 60050-195:1998/AMD1:2001, 195-04-01]

3.31
(electrically) instructed person
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/AMD1:2001, 195-04-02]

3.32
ordinary person
person who is neither a skilled person nor an instructed person

[SOURCE: IEC 60050-195:1998, 195-04-03]

3.33
step voltage
voltage between two points on the Earth's surface that are 1 m distant from each other

Note 1 to entry: 1 m is considered to be the stride length of a person

[SOURCE: IEC 60050-195:1998, 195-05-12, modified – “, which is considered to be the stride length of a person” …deleted and Note 1 to entry added]

3.34
potential grading
control of the earth potential, especially the earth surface potential, by means of earth electrodes

3.35
danger zone
in the case of high voltage, area limited by the minimum clearance around hazardous-live-parts without complete protection ~~against direct contact~~

Note 1 to entry: Entering the danger zone is considered the same as touching hazardous-live-parts.

3.36
leakage current
electric current in an ~~unwanted~~ unintended conductive path under normal ~~operating~~ conditions

[SOURCE: IEC 60050-195:1998, 195-05-15, modified – "unintended" replaces "unwanted"]

3.37
stationary equipment
~~– fixed equipment, or~~

~~– permanently connected equipment, or~~

~~– equipment that, due to its physical characteristics, is normally not moved and is normally plugged into the same socket-outlet~~

fixed equipment or electric equipment not provided with a carrying handle and having such a mass that it cannot easily be moved

Note 1 to entry: The value of this mass is minimum 18 kg in IEC standards relating to household appliances.

[SOURCE: IEC 60050-826:2004, 826-16-06, modified – "minimum" added to Note 1 to entry]

3.38
protective conductor current
electric current ~~which flows~~ appearing in a protective conductor, such as leakage current or electric current resulting from an insulation fault

~~(see 3.2 of IEC 60990)~~

[SOURCE: IEC 60050-826:2004, 826-11-21]

3.39
system
set of interrelated elements considered in a defined context as a whole and separated from their environment

~~NOTE 1 Such elements may be both material objects and concepts as well as the results thereof (e.g. forms of organization, mathematical methods, programming languages).~~

~~NOTE 2 The system is considered to be separated from the environment and from the other external SYSTEMS by an imaginary surface, which cuts the links between them and the system.~~

[SOURCE: IEC 60050-351:2013, ~~351-11-01~~ 351-42-08, modified – Notes deleted]

3.40
(electrical) installation
assembly of associated electric~~al~~ equipment having coordinated characteristics to fulfil ~~a~~ specific ~~purpose or~~ purposes ~~and having co-ordinated characteristics~~

[SOURCE: IEC 60050-826:2004, 826-10-01]

3.41
isolation
function intended to disconnect and maintain for reasons of safety adequate clearance from every source of electric energy

3.42
impulse withstand voltage
peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified conditions

3.43
electric burn
burning of the skin or an organ caused by an electric current along its surface or through it

[SOURCE: IEC 60050-195:1998, 195-03-01]

3.44
protective provision
independent provision intended to protect against electric shock under specified conditions

Note 1 to entry: The provision may be a means or technique or device or process.

3.45
protective measure
appropriate combination of protective provisions for protection against electric shock

4 Fundamental rule of protection against electric shock

4.1 General

Electric shock is defined as the physiological effect resulting from an electric current passing through a human body or livestock. The physiological effect might be harmful (such as ventricular fibrillation, burns, asphyxiation), see 4.2 to 4.5, or non-harmful (such as muscular reaction, perception), see 4.6.

Hazardous-live-parts shall not be accessible and accessible-conductive-parts shall not be hazardous live either:

– under normal conditions (operation in intended use, see 3.6 of ISO/IEC Guide 51:2014, and absence of a fault); or

– under single-fault conditions ~~(see also 2.8 of IEC Guide 104)~~.

NOTE ~~1~~ The accessibility rules for ordinary persons ~~may~~ can differ from those for skilled or instructed persons and ~~may~~ can also vary for different products and locations.

~~NOTE 2~~ For high-voltage installations, systems and equipment, entering the danger zone is considered the same as touching hazardous-live-part.

Protection under normal conditions (see 4.2) is provided by basic protection. Protection under single-fault conditions (see 4.3) is provided by fault protection. Additional protection is specified as part of a protective measure (see 4.4), where applicable.

Enhanced protective provisions (see 4.3.3) provide protection under both normal and single-fault conditions.

4.2 Normal conditions

To meet the fundamental rule for protection against electric shock under normal conditions, basic protection, as specified in this standard, is necessary.

The requirements for provisions for basic protection are given in 5.2.

In order to provide requirements for installations and for equipment, the following bands are specified:

- High voltage (HV)

  where protection against electric shock is ensured by special measures, in particular earthing arrangements.

- Low voltage (LV)

  where protection against electric shock is ensured by basic protection and in general also fault protection.

  Extra-low-voltage (ELV) is a part of the LV band.

When ELV is applied, fault protection may not be needed, and under certain conditions basic protection is provided by limitation of voltage. These conditions include contact area, moisture, voltage, current, and others defined for particular applications.

Table 1 specifies the different voltage limits for the above mentioned bands.

The values in Table 1 are based on the following conditions:

- a.c. systems:
  - for earthed systems by the r.m.s. values of the voltages between line and earth and between lines;
  - for isolated or not effectively earthed systems, by the r.m.s. value of the voltage between lines.
- d.c. systems:
  - for earthed systems by values of the voltages between line and earth and between lines;
  - for isolated or not effectively earthed systems, by the value of the voltage between lines.

Table 1 – Limits for voltage bands

Voltage band		a.c.	d.c.
HV		> 1 000 V	> 1 500 V
LV		≤ 1 000 V	≤ 1 500 V
	ELV	≤ 50 V	≤ 120 V

The upper limit of ELV of 120 V d.c. has for many years been agreed by convention. However, different environmental and contact situations as described in IEC TS 60479-1 cause different values of touch current, for a given voltage. Also the waveform of the current and the path taken through the body strongly influences the level of danger. Therefore, technical committees are requested to consider very carefully whether an ELV value less than 120 V d.c. might be necessary for their specific standard.

4.3 Single-fault conditions

4.3.1 General

Single faults shall be considered, if they would

– cause an accessible, non-hazardous-live-part to become a hazardous-live-part (e.g. due to failure to limit the steady-state touch current and charge); or

– cause an accessible conductive part which is not live under normal conditions to become a ~~hazardously~~ hazardous-live-part (e.g. due to failure of basic insulation to exposed-conductive-parts); or

– cause a hazardous-live-part to become accessible (e.g. by mechanical failure of an enclosure[1]).

To meet the fundamental rule under single-fault conditions, fault protection, and in certain cases additional protection, is necessary. This protection can be achieved by

– a further protective provision, independent of that for basic protection (see 4.3.2), or

[1] ~~It is recognized that this aspect has not been dealt with up till now. Appropriate mechanical requirements and tests will be needed. They cannot be replaced by the specification of electrical parameters.~~

– an enhanced protective provision (see 4.3.3) which provides both basic and fault protection,

taking account of all relevant influences.

The requirements for provisions for fault protection are given in 5.3.

~~NOTE For low-voltage installations, systems and equipment, fault protection generally corresponds to protection against indirect contact as used in IEC 60364-4-41, in particular the failure of basic insulation.~~

4.3.2 Protection by ~~two~~ independent protective provisions

Each of the ~~two~~ independent protective provisions shall be designed so that a failure is unlikely under conditions specified by the relevant technical committee.

The ~~two~~ independent protective provisions shall have no influence on each other such that a failure of one of the protective provisions could impair ~~the other~~ another.

Simultaneous failure of ~~the two~~ independent protective provisions is unlikely and need not normally be taken into consideration. Reliance is placed on ~~one of~~ the unaffected protective provisions remaining effective.

4.3.3 Protection by an enhanced protective provision

The properties of an enhanced protective provision shall be such that the same continued effectiveness of protection as provided by two independent protective provisions is achieved. Requirements for enhanced protective provisions are given in 5.4.

4.4 ~~Special cases~~ Additional protection

If the intended use implies an increased inherent risk, e.g. for areas with a low-impedance contact of persons with earth potential, technical committees shall consider the possible need to specify additional protection. Such additional protection may be provided in the installation, in the system or in the equipment.

~~NOTE In the case of low-voltage installations and equipment, the use of residual current devices, with a rated residual operating current not exceeding 30 mA, is recognized as additional protection against electric shock where basic and/or fault protection is not effective or by careless use of equipment .~~

~~The consequences of double or even multiple faults may have to be considered, in special cases, subject to judgement by technical committees.~~

Requirements for additional protection are given in 5.5.

Single fault conditions resulting in one or multiple subsequent failures shall be considered as a single fault condition.

4.5 Protection against electric burns

Technical committees shall specify measures to protect against electric burns in their standards.

An electric burn can be caused where a current of sufficient density and duration flows through the human body or livestock. Arcs can also cause burns.

The effects can be severe even if only a small part of the body is involved.

NOTE 1 Deep-seated burns and other internal injuries, or surface burns can occur.

NOTE 2 Technical information on electric burns can be found in IEC TS 60479-1 and measurement technique in IEC 60990 for many cases.

4.6 Protection against physiological effects without adverse health effect

4.6.1 General

Technical committees shall consider whether the following effects are to be taken into account in their standards.

Current flowing through a human body without being directly harmful may cause situations which are inconvenient or hazardous (such as results of startle reaction).

This may concern threshold of perception or threshold of pain or heat sensation.

4.6.2 Muscular reaction

Involuntary muscular contractions are likely to occur, when currents through the human body or livestock are flowing in the range of areas AC-2 of the time/current zones, for a.c. 15 Hz to 100 Hz, and in the range of areas DC-2 of the time/current zones, for d.c., according to IEC TS 60479-1.

For alternating current with a frequency not exceeding 100 Hz, or for a direct current with ripple not exceeding 10 %, the touch voltage threshold for reaction shall not exceed the values in Table 2:

Table 2 – Touch voltage thresholds for reaction

Type of reaction	Voltage threshold
Startle reaction	2 V a.c. or 8 V d.c
Muscular reaction	20 V a.c. or 40 V d.c

These values of Table 2 are defined for dry conditions and a contact area of 35 cm^2.

If other environmental conditions, such as salt water wet, water wet or immersed are considered, these values may be reduced, depending also on the current path through the body.

4.6.3 Effects of touch current of discharge of electrostatic charges

Startle reactions are likely to occur when currents resulting from electrostatic discharge are flowing in the human body or livestock.

4.6.4 Thermal effects

Heat sensation can be experienced, when even small values of current are flowing through the human body or livestock. The effect may be more evident at higher frequencies.

Effects such as rise in blood pressure, immobilization, disturbances of formation and conduction of cardiac impulses (including atrial fibrillation and transient rhythm disturbances) may occur.

5 Protective provisions (elements of protective measures)

5.1 General

Subclauses 5.2 to 5.5 give an overview of the different protective provisions. Protective measures result from a suitable combination of them. The structure of typical protective measures is described in Clause 6.

All protective provisions shall be designed and constructed to be effective during the anticipated lifetime of the installation, of the system or of the equipment when used as intended and properly maintained.

The environment ~~should~~ shall be taken into account by use of the classification of external influences as described in the IEC 60721 series and for testing in the IEC 60068 series. Attention is particularly drawn to the ambient temperature, climatic conditions, presence of water, mechanical stresses, capability of persons and area of contact of persons or ~~animals~~ livestock with earth potential.

Technical committees shall take account of the requirements for insulation coordination. For low-voltage installations, systems and equipment these requirements are found in the IEC 60664~~-1~~ series which also gives dimensioning rules for clearances (in air) and creepage distances as well as dimensioning guidance for solid insulation. For high-voltage installations, systems and equipment, the requirements are found in IEC 60071-1 and IEC 60071-2.

5.2 Provisions for basic protection

5.2.1 General

Basic protection shall consist of one or more provisions that, under normal conditions, prevent contact with hazardous-live-parts.

NOTE Paints, varnishes, lacquers and similar products alone are generally not considered to provide adequate insulation for protection against electric shock in normal service.

Subclauses 5.2.2 to 5.2.9 specify some individual provisions for basic protection.

5.2.2 Basic insulation

5.2.2.1 Where solid basic insulation is used, it shall prevent contact with hazardous-live-parts.

~~NOTE~~ In case of high-voltage installations and equipment, a voltage may be present on the surface of solid insulation and further precautions ~~may~~ shall be ~~necessary~~ considered.

5.2.2.2 Where basic insulation is provided by air, access to hazardous-live-parts or entering the danger zone shall be prevented by obstacles, protective barriers or enclosures as specified in 5.2.3 and 5.2.4 or by placing out of arm's reach as specified in 5.2.5.

5.2.3 Protective barriers or enclosures

5.2.3.1 Protective barriers or enclosures shall prevent:

– in the case of low-voltage installations and equipment, access to hazardous-live-parts by providing a degree of protection against electric shock of at least IPXXB ~~(also complied with by~~ or IP2X~~)~~ of IEC 60529 and, for readily accessible horizontal top surfaces of protective barriers or enclosures, at least IPXXD or IP4X

– in the case of high-voltage installations and equipment, entering the danger zone by providing a degree of protection of at least IPXXB ~~(also complied with by~~ or IP2X~~)~~ of IEC 60529, and consideration shall be given to providing a degree of protection of at least IPXXD or IP4X for readily accessible horizontal top surfaces of protective barriers or enclosures

NOTE The IP code applies to the enclosures of electrical equipment of rated voltage not exceeding 72,5 kV.

5.2.3.2 Protective barriers or enclosures shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection, taking account of all relevant influences from the environment and from inside the enclosure. They shall be firmly secured in place.

5.2.3.3 Where the design or construction allows for the removal of protective barriers, the opening of enclosures or the removal of parts of enclosures, access to hazardous-live-parts or entering the danger zone shall be possible only

– by the use of a key or tool, or

– after isolation of hazardous-live-parts from the supply circuit where the enclosure would no longer provide protection, restoration of the supply shall become possible only after replacement of protective barriers or parts of enclosures or after the closing of doors, or

– where an intermediate barrier still maintains the required degree of protection, such barrier being removable only by the use of a key or tool.

NOTE See also Clause 8.

5.2.4 Obstacles

5.2.4.1 Obstacles are intended to protect skilled or instructed persons but ~~are not intended to protect~~ their use is not permitted for the protection of ordinary persons.

5.2.4.2 During the operation of the installation, system or equipment under special operating and servicing conditions (see Clause 8), obstacles shall prevent:

– in the case of low-voltage installations and equipment, unintentional contact with hazardous-live-parts, or

– in the case of high-voltage installations and equipment, unintentional entering the danger zone.

5.2.4.3 Obstacles may be removable without using a key or tool but shall be so secured as to make unintentional removal unlikely.

5.2.4.4 Where a conductive obstacle is separated from hazardous-live-parts by basic insulation only, it is considered to be an exposed-conductive-part, and measures for fault protection (see Clause 6) shall also be applied.

5.2.5 Placing out of arm's reach

5.2.5.1 Where provisions specified in 5.2.2, 5.2.3, 5.2.4, 5.2.6 and 5.2.7 are found to be not applicable, placing out of arm's reach may be appropriate to prevent

– in the case of low-voltage installations and equipment, unintentional simultaneous access to conductive parts between which a hazardous voltage can exist,

– in the case of high-voltage installations and equipment, unintentional entering into the danger zone.

Details shall be specified by technical committees.

~~NOTE~~ For low-voltage installations, parts that are separated by a distance of more than 2,5 m are normally considered not to be simultaneously accessible. Where access is restricted to skilled or instructed persons, reduced distances may be specified.

5.2.5.2 Where a distance is expected to be reduced by objects which a person uses or holds in the hand, such as a tool or a ladder, technical committees shall specify relevant restrictions, or an appropriate distance between conductive parts between which a hazardous voltage can exist.

5.2.6 Limitation of voltage

~~Limitation of voltage shall provide that the voltage between simultaneously accessible parts does not exceed relevant ELV limits as specified in IEC 61201.~~

~~NOTE This provision for basic protection does not refer to the necessary provisions for fault protection, see 6.6 and 6.7.~~

Basic protection by the provision of limitation of voltage is fulfilled where both of the following conditions are fulfilled:

a) touch voltage under no circumstances exceeds:

   1) 25 V a.c. r.m.s. or 60 V ripple-free d.c., when the equipment is normally used in dry locations only and large-area contact of live parts with the human body is not to be expected;

   2) 6 V a.c. r.m.s. or 15 V ripple-free d.c. in all other cases;

b) the safety level is equivalent to that for SELV or PELV and supplied by one of the following sources:

   1) a safety isolating transformer;

      NOTE Safety isolating transformers are those that comply with IEC 61558-2-6.

   2) a source of current providing a degree of safety equivalent to that of a safety isolating transformer (e.g. motor generator);

   3) electrochemical (e. g. battery).

It shall be acknowledged that the precise value of this voltage limit depends on a great number of influencing factors (such as environmental conditions, contact area).

5.2.7 Limitation of steady-state touch current and ~~charge~~ energy

Limitation of steady-state touch current and ~~charge~~ energy is a provision whereby touch currents or energy is limited to non-dangerous values.

It shall prevent persons or ~~animals~~ livestock from being subjected to values of steady-state touch current and ~~charge~~ energy liable to be ~~hazardous or perceptible~~ above the values given in Clause 5.

~~NOTE For persons, the following values (a.c. values for frequencies up to 100 Hz) are given as guidance:~~

a) For touch current, the following values are proposed:

   – a steady-state current flowing between simultaneously accessible conductive parts ~~through a pure resistance of 2 000 Ω~~ not exceeding the threshold of perception, 0,5 mA a.c. or 2 mA d.c. ~~are recommended~~ under normal operating conditions;

   – values not exceeding the threshold of pain 3,5 mA a.c. or 10 mA d.c. may be specified under abnormal or fault conditions.

~~–~~b) ~~A~~ For stored ~~charge~~ energy available between simultaneously accessible conductive parts, ~~not exceeding 0,5 µC (threshold of perception) is recommended, and 50 µC (threshold of pain) may be specified~~ the following values are proposed according to Figure 19 of IEC TS 60479-2:2007:

   – 0,5 mJ corresponding to the threshold of pain; and

   – 5 µJ corresponding to the threshold of perception.

– ~~Technical committees may specify higher values of stored charge and steady-state current for parts specially required to stimulate reaction (e.g. electric fence). Attention is drawn to the threshold of ventricular fibrillation, see IEC 60479-1.~~

– ~~The limit values for steady-state a.c. current are given for sinusoidal current with frequencies between 15 Hz and 100 Hz. Values for other frequencies, for other waveforms and for a.c. with superimposed d.c. are under consideration.~~

Values for other frequencies, for other waveforms and for a.c. with superimposed d.c. are properly considered when measured with the appropriate IEC 60990 filtered touch current circuit.

– NOTE Medical electrical equipment within the scope of the IEC 60601 series ~~may~~ can necessitate other levels.

5.2.8 Potential grading

In the case of high-voltage installations and equipment, potential grading shall prevent persons or ~~animals~~ livestock from hazardous step and touch voltages under normal conditions by providing a potential grading earth electrode.

NOTE Potential grading is typically used for electrical railway systems and substations, where high earth currents occur.

5.2.9 Other provisions for basic protection

Any other provision for basic protection shall comply with the ~~fundamental rule (see clause 4)~~ requirements of 4.1 for protection against electric shock.

5.3 Provisions for fault protection

5.3.1 General

Fault protection shall consist of one or more provision(s) independent of and additional to those for basic protection.

Subclauses 5.3.2 to 5.3.9 specify individual provisions for fault protection.

5.3.2 Supplementary insulation

Supplementary insulation is a provision whereby fault protection is provided by an insulation in addition to basic insulation.

Supplementary insulation shall be dimensioned to withstand the same stresses as specified for basic insulation.

5.3.3 Protective-equipotential-bonding

5.3.3.1 General

Protective-equipotential-bonding is a provision whereby items are bonded together to avoid hazardous touch voltages.

The protective-equipotential-bonding system shall consist of one or a suitable combination of two or more of the elements below:

– ~~means for~~ protective-equipotential-bonding in equipment, see Clause 7;
– earthed or unearthed protective-equipotential-bonding in the installation ~~(see note)~~;
– protective conductor (PE);
– PEN, PEL or PEM conductor;
– protective screen~~ing~~;

– earthed point of the source or artificial neutral point;

– earth electrode (including earth electrodes for potential grading);

– earthing conductor.

~~NOTE In low-voltage installations, earthed protective-equipotential-bonding commonly consists of~~

~~– main equipotential bonding connecting together~~

~~• main protective conductor;~~

~~• main earthing conductor or main earthing terminal;~~

~~• metallic pipes supplying services within the building, e.g. gas, water;~~

~~• structural metallic parts, central heating and air-conditioning systems, if applicable;~~

~~• any metallic sheath of cables (for telecommunication cables, if permitted by the owners or operators of these cables)~~

~~– supplementary equipotential bonding connecting accessible conductive parts together~~

~~– local equipotential bonding connecting accessible conductive parts together in a local area where specific conditions exist.~~

The equipotential bonding system of a high-voltage installation or system shall be connected to earth because of the special risks, which may be present, e.g. the danger of high touch and step voltage and of exposed-conductive-parts becoming live due to electrical discharge. The impedance to earth of the earthing arrangement shall be rated so that no hazardous touch voltage can occur. Exposed-conductive-parts, which can become live under fault conditions, shall be connected to the earthing arrangement.

5.3.3.2 Accessible conductive parts which could acquire a hazardous effective touch voltage in the event of a failure of basic protection, i.e. exposed-conductive-parts and any protective screen, shall be connected to the protective-equipotential-bonding system.

NOTE A conductive part of electrical equipment 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.

5.3.3.3 The protective-equipotential-bonding system shall be of sufficiently low impedance to avoid hazardous potential difference between conductive parts in case of an insulation failure ~~and, if~~. Where necessary~~, be~~ the protective-equipotential-bonding system shall be used in association with a protective device operated by the fault current (see 5.3.6). The maximum difference in potential and its duration shall be based on IEC ~~60479-1~~ TR 60479-5.

~~NOTE 1~~ This may necessitate consideration of the relative impedance values of the different elements of a protective-equipotential-bonding system.

~~NOTE 2~~ The difference in potential need not be considered if the impedance of the circuit limits the steady-state touch current in the case of a single fault so that it cannot exceed 3,5 mA a.c., r.m.s. ~~for frequencies up to 100 Hz~~ or 10 mA d.c. when measured in accordance with IEC 60990.

~~NOTE 3~~ In some environments or situations, e.g. medical locations (see limit values in IEC 60601-1), highly conductive locations, wet areas and similar areas, the limit values need to be lower.

5.3.3.4 All parts of the protective-equipotential-bonding system shall be so dimensioned that thermal and dynamic stresses which are likely to occur ~~due to a fault current~~ do not impair the characteristics of the protective-equipotential-bonding system, e.g. as a consequence of a failure or bridging of basic insulation.

~~NOTE Some local damage, not impairing safety, e.g. of a sheet metal part of an enclosure, may be accepted at the place where the fault occurs according to specific indications given by product committees.~~

5.3.3.5 All parts of the protective-equipotential-bonding system shall be capable of withstanding all internal and external influences (including mechanical, thermal and corrosive) which may be expected.

5.3.3.6 Movable conductive connections, e.g. hinges and slides, shall not be considered to be parts of a protective-equipotential-bonding system unless compliance with the requirements of 5.3.3.3, 5.3.3.4 and 5.3.3.5 is maintained.

5.3.3.7 Where a component of an installation, system or equipment is intended to be removed, the protective-equipotential-bonding for any other part of the installation, system or equipment shall not be interrupted when removing the component unless the electrical supply to the other part is first disconnected.

5.3.3.8 With the exception described in 5.3.3.9, no element of the protective-equipotential-bonding system shall contain any device which might reasonably be expected to break the electrical continuity or introduce significant impedance.

~~NOTE~~ This requirement may be dispensed with by technical committees for the verification of the continuity of protective conductors or for measuring of the current of the protective conductor.

5.3.3.9 Where elements of the protective-equipotential-bonding system can be interrupted by the same coupler or plug-and-socket-outlet device as the relevant supply conductors, the protective-equipotential-bonding system shall not be interrupted before the supply conductors. The protective-equipotential-bonding shall be re-established not later than when the supply conductors are reconnected. These requirements do not apply where interruption and reconnection are possible only with the equipment in de-energized condition.

In high-voltage installations, systems and equipment, the protective-equipotential-bonding system shall not be interrupted before the main contact has reached an isolating distance which can withstand the equipment rated impulse withstand voltage.

5.3.3.10 Conductors of the protective-equipotential-bonding system, whether insulated or bare, shall be readily distinguishable by shape, location, marking or colour, except those conductors which cannot be disconnected without destruction, e.g. in wire-wrap and similar wiring in electronic equipment and tracks on printed wiring boards. If identification by colour is used, it shall be in accordance with IEC ~~60446~~ 60445.

Conductors used only for functional earthing shall not have insulation coloured green-and-yellow.

5.3.4 Protective screening

Protective screening shall consist of a conductive screen interposed between hazardous-live-parts of an installation, system or equipment and the part being protected. The protective screen

– shall be connected to the protective-equipotential-bonding system of the installation, system or equipment and that interconnection shall comply with the requirements of 5.3.3, and
– shall itself comply with the requirements for elements of protective-equipotential-bonding system, see 5.3.3.3, 5.3.3.4 and 5.3.3.5.

5.3.5 Indication and disconnection in high-voltage installations and systems

A device shall be provided which indicates a fault. Depending on the method of neutral earthing, the fault current shall be disconnected either manually or automatically (see 5.3.6). The permissible value of the touch voltage depending on the fault duration shall be specified by technical committees based on IEC TS 60479-1.

5.3.6 Automatic disconnection of supply

5.3.6.1 General

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 conductor(s) supplying the equipment, system or installation, in the event of a ~~failure of basic insulation~~ fault of negligible impedance between a line conductor and an exposed-conductive-part or a protective conductor in the circuit or equipment.

For low-voltage applications, devices for protection against electric shock by automatic disconnection of supply shall be suitable for isolation according to 8.4. For high-voltage see 8.4.3.

5.3.6.2 The protective device shall interrupt the fault current within a time specified by technical committees based on the IEC 60479~~-1~~ series. For low-voltage installations, the time to be specified depends on the prospective touch voltage produced across the protective-equipotential-bonding.

~~NOTE~~ For steady-state fault currents which, with regard to protection against electric shock, need not lead to disconnection, a conventional touch voltage limit U_L may be specified.

5.3.6.3 The protective device may be provided in any suitable upstream part of the installation, system or equipment, preferably at the origin of the circuit to be protected, and shall be selected taking into account the characteristics of the supply and the load, and of the impedance of the fault current loop.

5.3.7 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.

A component connected between the separated circuits shall withstand the electric stresses specified for the insulation which it bridges and its impedance shall limit the prospective current flow through the component to the steady-state touch current values indicated in 5.2.7.

5.3.8 Non-conducting environment

The environment shall have an impedance to earth of at least

– 50 kΩ if the nominal system voltage does not exceed 500 V a.c. or d.c.;

– 100 kΩ if the nominal system voltage is above 500 V a.c. or d.c. and does not exceed 1 000 V a.c. or 1 500 V d.c. ~~(a.c. values for frequencies up to 100 Hz)~~.

NOTE 1 Methods for measuring the resistance of insulating floors and walls are included in Annex A to IEC ~~60364-6-61~~ 60364-6: 2006.

NOTE 2 Impedance values for HV are ~~under consideration~~ not considered because this protective measure is not used.

5.3.9 Potential grading

Potential grading may be used by installation of additional earth electrodes to reduce the touch voltage and step voltage which appear in the case of a fault.

NOTE Earth electrodes are usually buried at a horizontal distance of 1 m ~~in front of~~ from the equipment or any conductive part, at a depth of 0,5 m below ground level and are connected to the earthing arrangement.

5.3.10 Other provisions for fault protection

Any other provision for fault protection shall comply with the ~~fundamental rule (see clause 4)~~ requirements of 4.1 for protection against electric shock.

5.4 Enhanced protective provisions

5.4.1 General

An enhanced protective provision shall provide both basic and fault protection.

Subclauses 5.4.2 to 5.4.6 specify such enhanced provisions.

Arrangements shall be made so that the protection provided by an enhanced protective provision is unlikely to become degraded and so that a single fault is unlikely to occur.

5.4.2 Reinforced insulation

Reinforced insulation shall be designed 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 3.10.1 and 3.10.2, respectively).

~~NOTE 1~~ This requires design and test parameters more severe than those specified for basic insulation (see IEC 60664-1).

NOTE 1 As an example for low-voltage applications, dimensioning of reinforced insulation with regard to impulse voltage is, where the concept of overvoltage categories (see Clause 443 of IEC ~~60364-4-443~~ [2] 60364-4-44:2007) applies, specified to comply with the requirements of the overvoltage category which is one category higher than that specified for basic insulation.

NOTE 2 Reinforced insulation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

5.4.3 Protective separation between circuits

Protective separation between a circuit and other circuits shall be achieved by means of

– basic insulation and supplementary insulation, each rated for the highest voltage present, i.e. double insulation, or
– reinforced insulation (see 5.4.2) rated for the highest voltage present, or
– protective screening (see 5.3.4) with the protective screen being separated from each adjacent circuit by basic insulation rated for the adjacent circuit voltage (see also 6.6~~, last paragraph~~), or
– 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 5.4.5.

5.4.4 Limited current source

A limited current source shall be so designed that it cannot supply touch currents in excess of the limit values indicated in 5.2.7.

~~2 This standard is due to be replaced by IEC 60364-4-44.~~

The requirements of 5.2.7 apply also to any likely failure[3] of a single component of the limited current source.

NOTE The limit values should be determined by the relevant technical committee.

5.4.5 Protective impedance device

A protective impedance device shall reliably limit the touch current to the values indicated in 5.2.7.

The protective impedance device shall withstand the electric stresses specified for the insulation which it bridges.

These requirements apply also to any likely failure[3] of a single component of the protective impedance device.

5.4.6 Other provisions for enhanced protection

Any other enhanced protective provision for both basic protection and fault protection shall comply with the fundamental rule (see clause 4) requirements of 4.1 for protection against electric shock.

5.5 Provisions for additional protection

5.5.1 Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30$ mA

In the case of low voltage, an RCD with $I_{\Delta n} \leq 30$ mA is applied as an additional protective provision where

a) basic protection is provided by one of the provisions of 5.2.2 (basic insulation) or 5.2.3 (protective barriers or enclosures), and/or

b) fault protection is provided by one of the provisions of 5.3.3 (protective-equipotential-bonding) and 5.3.6 (automatic disconnection of supply).

This protective provision is recognized as additional protection in the event of failure of the provision for basic protection and/or the provision for fault protection, or carelessness by users.

Devices for additional protection shall disconnect the live conductors by providing an isolating distance according to 8.4.

Residual current monitoring devices (RCMs) are not considered to be protective devices.

5.5.2 Additional protection by supplementary equipotential bonding

Additional protection by supplementary equipotential bonding is a provision whereby dangerous touch voltages are avoided by bonding of items.

Supplementary equipotential bonding is provided as an additional protective provision where

a) basic protection is provided by one of the provisions of 5.2.2 (basic insulation) or 5.2.3 (protective barriers or enclosures), and

b) fault protection is provided by protective earthing, protective equipotential bonding (5.3.3) and automatic disconnection in the event of a fault (5.3.6).

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[3] For example, where the relevant safety characteristics of a component are specified and controlled by the IEC Quality System for Electronic Components (IECQ), failure of correctly used approved components is not considered to be likely.

This protective provision will help avoid hazardous voltages between exposed-conductive-parts and extraneous-conductive-parts which can be touched simultaneously.

6 Protective measures

6.1 General

Clause 6 describes the structure of typical protective measures, indicating in some cases which protective provision(s) are for basic protection ~~and which are~~, for fault protection and for additional protection.

More than one of the following protective measures (see from 6.2 to 6.11) may be used within the same installation, system or equipment both under normal operating conditions and under single fault conditions.

The use of ELV other than that in accordance with 6.7 and 6.8 is not a protective measure.

6.2 Protection by automatic disconnection of supply

~~Protective measure in which~~ Automatic disconnection of supply shall consist of a combination of the following protective provisions:

– basic protection is provided by basic insulation, or protective barriers or enclosures between hazardous-live-parts and exposed-conductive-parts; and

– fault protection is provided by automatic disconnection of supply.

~~NOTE~~ Automatic disconnection of supply requires, according to 5.3.6, a protective-equipotential-bonding system as specified in 5.3.3. The relevant maximum disconnection times can be derived from IEC 60364-4-41.

6.3 Protection by double or reinforced insulation

Protective measure in which

– basic protection is provided by basic insulation of hazardous-live-parts and fault protection is provided by supplementary insulation,

or

– basic protection and fault protection are provided by reinforced insulation between hazardous-live-parts and accessible parts (accessible conductive parts and accessible surfaces of insulating material).

6.4 Protection by protective equipotential bonding

Protective measure in which

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts, and

– fault protection is provided by a protective equipotential bonding system preventing hazardous voltages between simultaneously accessible exposed and extraneous-conductive-parts.

6.5 Protection by electrical separation

~~Protective measure in which~~ Electrical separation is achieved where the following conditions are met:

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts of the separated circuit; and

– fault protection is provided

- by simple separation of the separated circuit from other circuits and earth, and
- by ~~an earth-free~~ a protective-equipotential-bonding interconnecting exposed-conductive-parts of the separated circuit where more than one item of equipment is connected to the separated circuit. This protective-equipotential-bonding system shall not be earthed.

Intentional connection of exposed-conductive-parts to a protective earthing conductor or to an earthing conductor is not permitted.

NOTE Electrical separation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

~~NOTE 2 Electrical separation given in 413.5 of IEC 60364-4-41 for low-voltage installations contains more stringent requirements.~~

6.6 Protection by non-conducting environment (low-voltage)

Protective measure in which

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts, and
– fault protection is provided by the non-conducting environment.

6.7 Protection by SELV system

Protective measure in which protection is provided by

– limitation of voltage in a circuit to ELV limits as defined in Table 1 (the SELV system), and
– protective separation of the SELV system from all circuits other than SELV and PELV, and
– simple separation of the SELV system from other SELV systems, from PELV systems and from earth.

Intentional connection of exposed-conductive-parts to a protective conductor or to an earthing conductor is not permitted.

In special locations where SELV is required and where protective screening according to 5.3.4 is applied, the protective screen shall be separated from each adjacent circuit by basic insulation intended for the highest voltage present.

6.8 Protection by PELV system

Protective measure in which protection is provided by:

– limitation of voltage in a circuit ~~which~~ to ELV limits as defined in Table 1 and the circuit may be earthed and/or the exposed-conductive-parts of which may be earthed (the PELV system); and
– protective separation of the PELV system from all circuits other than SELV and PELV.

If the PELV circuit is earthed and if protective screening according to 5.3.4 is used, it is not necessary to provide basic insulation between the protective screen and the PELV system.

NOTE Where live parts of the PELV system are accessible simultaneously with conductive parts which, in case of a fault, could assume the potential of the primary circuit, protection against electric shock depends on protective-equipotential-bonding between all such conductive parts.

~~NOTE 2 The use of ELV other than that in accordance with 6.6 and 6.7 is not a protective measure.~~

6.9 Protection by limitation of steady-state touch current and charge

Protective measure in which protection is provided by

– supply of a circuit:
  - from a limited current source, or
  - through a protective impedance device,

and

– protective separation of the circuit from hazardous-live-parts.

6.10 Additional protection

6.10.1 Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30$ mA

An RCD with $I_{\Delta n} \leq 30$ mA is used in addition to

– basic protection by basic insulation according to 5.2.2 or 5.2.3; and/or
– fault protection by one of the provisions of 5.3.3, 5.3.6 or 5.3.10.

The RCD for additional protection shall be suitable for isolation.

6.10.2 Additional protection by supplementary protective equipotential bonding

Supplementary protective-equipotential-bonding is used in addition to

– basic protection by basic insulation between hazardous-live-parts and exposed-conductive-parts, and
– fault protection by one of the provisions of 5.3.2, 5.3.3 or 5.3.10

by applying protective-equipotential-bonding to avoid hazardous voltages between exposed-conductive-parts and extraneous-conductive-parts which can be touched simultaneously.

6.11 Protection by other measures

Any other protective measure shall comply with the ~~fundamental rule (see clause 4)~~ requirements of 4.1 for protection against electric shock and provide basic protection and fault protection.

7 Co-ordination ~~of~~ between electrical equipment and ~~of~~ protective provisions within an electrical installation

7.1 General

Protection is achieved by a combination of the constructional arrangements for the equipment and devices, together with the method of installation. Technical committees are recommended to use the protective measures described in Clause 6.

~~Equipment may~~ Current using equipment shall be classified in accordance with the classes of 7.2 to 7.5. The use of protective provisions in the several classes of equipment is described in 7.2 to 7.5 (see also Table 3).

If it is not appropriate to classify equipment and devices in this way, technical committees shall then specify the relevant methods of installation for their products.

For some equipment, the compliance with the classification can be achieved only after installation, e.g. where the installation prevents access to live parts. In this case, suitable instructions shall be provided by the manufacturer or responsible vendor.

Different protective measures applied to the same installation or part of an installation or within equipment shall have no influence on each other such that failure of one protective measure could impair the other protective measure or measures.

Table ~~1~~ 3 – Application of equipment in a low-voltage installation

~~Class of equipment~~	~~Equipment marking or instructions~~	~~Conditions for connection of the equipment to the installation~~
~~Class 0~~	~~– Only for use in non-conducting environment; or~~	~~Non-conducting environment~~
	~~– Protected by electrical separation~~	~~Electrical separation provided for each equipment individually~~
~~Class I~~	~~Marking of the protective bonding terminal with symbol no. 5019 of IEC 60417-2, or letters PE, or colour combination green-yellow~~	~~Connect this terminal to the protective-equipotential-bonding of the installation~~
~~Class II~~	~~Marking with symbol no. 5172 of IEC 60417-2 (double square)~~	~~No reliance on installation protective measures~~
~~Class III~~	~~Marking with symbol no. 5180 of IEC 60417-2 (roman numeral III in a diamond)~~	~~Connect only to SELV or PELV systems~~

Class of equipment	Equipment marking or instructions	Symbol	Conditions for connection of the equipment to the installation
Class I	Marking of the protective bonding terminal with graphical symbol IEC 60417-5019:2006-08, or letters PE, or colour combination green-yellow		Connect this terminal to the protective-equipotential-bonding system of the installation
Class II	Marking with the graphical symbol IEC 60417-5172:2003-02 (double square)		No reliance on installation protective measures
Class III	Marking with the graphical symbol IEC 60417-5180:2003-02 (roman numeral III in a diamond)		Connect only to SELV or PELV systems

7.2 Class 0[4] equipment

Equipment with basic insulation as provision for basic protection and with no provisions for fault protection.

~~7.1.1 Insulation~~

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts.

Class 0 shall only be used for equipment intended for connection by means of cord and plug to circuits operating at voltage not exceeding 150 V to earth.

However it is recommended that product committees withdraw class 0 from their product standards.

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[4] ~~It is recommended to eliminate class 0 equipment from international standardization. However, class 0 has been included here because this class is still referred to in a few product standards.~~

7.3 Class I equipment

7.3.1 General

Equipment with ~~basic insulation as~~ at least one provision for basic protection and a connection to a protective ~~bonding~~ conductor as provision for fault protection.

7.3.2 Insulation

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts. This also applies to conductive parts which are separated by basic insulation but which are connected to hazardous-live-parts through components which are not designed for the same stresses as specified for basic insulation.

7.3.3 ~~Protective equipotential bonding~~ Connection to the protective conductor

Exposed-conductive-parts of the equipment shall be connected to the protective ~~bonding~~ conductor terminal.

NOTE ~~1~~ Exposed-conductive-parts include those parts which are covered only by paints, varnishes, lacquers and similar products.

~~NOTE 2~~ Conductive parts which can be touched are not exposed-conductive-parts if they are separated from hazardous-live-parts by protective separation.

7.3.4 Accessible surfaces of parts of insulating material

If the equipment is not completely covered with conductive parts, the following applies to accessible parts of insulating material:

Accessible surfaces of parts of insulating material which

– are designed to be ~~gripped~~ grasped, or
– are likely to come into contact with conductive surfaces which could distribute hazardous potential, or
– can come into significant contact (area more than 50 mm × 50 mm) with a part of the human body, or
– ~~the parts~~ are to be used in areas where the pollution is highly conductive,

shall be separated from hazardous-live-parts by

– double or reinforced insulation, or
– basic insulation and protective screening, or
– a combination of these provisions.

All other accessible surfaces of parts of insulating material shall be separated from hazardous-live-parts by at least basic insulation. For equipment intended to be part of the fixed installation, the basic insulation shall be provided either by the manufacturer or during installation as specified by the manufacturer or responsible vendor in his instructions.

These requirements are deemed to be complied with if the accessible parts of insulating material provide the required insulation.

~~NOTE~~ Technical committees may impose more stringent requirements than basic insulation for certain accessible parts of insulating material (e.g. which need to be touched frequently, such as operating means), taking into account the area of the contact surface with the human body.

7.3.5 Connection of a protective conductor

7.3.5.1 The means of connection, except for plug-and-socket connections, shall be clearly identified either with the graphical symbol ~~no. 5019 of~~ IEC ~~60417-2~~ 60417-5019:2006-08, or with the letters PE, or by the bi-colour combination of green and yellow according to IEC 60445. The indication shall not be placed on or fixed by screws, washers or other parts which might be removed when conductors are being connected.

7.3.5.2 For ~~cord~~ flexible cable connected equipment, including fixed and plug-and-socket types, provisions shall be made such that the protective conductor in the cord shall, in case of failure of the strain-relief mechanism, be the last conductor to be interrupted.

7.4 Class II equipment

7.4.1 General

Class II equipment comprises equipment with

– 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.

7.4.2 Insulation

7.4.2.1 The accessible conductive parts and the accessible surfaces of parts of insulating material shall either be

– separated from hazardous live-parts by double or reinforced insulation, or

– designed with constructional arrangements providing equivalent protection, e.g. a protective impedance device.

For equipment intended to be part of the fixed installation, this requirement shall be fulfilled when the equipment is properly installed. This means that the insulation (basic, supplementary or reinforced) and the protective impedance, if relevant, shall be provided either by the manufacturer or during installation as specified by the manufacturer or responsible vendor in his instructions.

~~NOTE~~ Arrangements providing equivalent fault protection may be defined by technical committees along with requirements appropriate to the nature of the equipment and its application.

7.4.2.2 All conductive parts which are separated from hazardous-live-parts by basic insulation only or by constructional arrangements providing equivalent protection shall be separated from the accessible surface by supplementary insulation or by constructional arrangements providing equivalent protection.

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts, i.e. they shall be separated from the accessible surface in accordance with 7.4.2.1.

7.4.2.3 The enclosure shall not contain any screws or other fixing means of insulating material where these screws or other fixing means need to be removed or are likely to be removed during installation and maintenance and where the replacement of which by metallic screws or other fixing means could impair the insulation required.

7.4.2.4 The insulation of class II equipment shall comply with 5.1.6 of IEC 60664-1:2007.

7.4.3 Protective bonding

~~Conductive parts which can be touched and intermediate parts shall not intentionally be connected to any means of connection for a protective conductor.~~

7.4.3.1 Class II equipment shall not have a provision for connection to a protective conductor except for applications according to 7.4.3.2.

7.4.3.2 ~~If~~ Where a class II equipment is provided with means for maintaining the continuity of a protective ~~equipotential bonding~~ conductor, but in all other respects is constructed as class II equipment, such means shall be insulated in accordance with 7.4.2.1.

~~– insulated from live parts and accessible conductive parts of the equipment by basic insulation, and~~

~~– marked as required for class I equipment.~~

~~The equipment shall not be marked with the symbol referred to in 7.3.3.~~

Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which run through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be marked as PE terminals.

7.4.3.3 Class II equipment may be provided with means for connection to earth for functional (as distinct from protective) purposes only where such a need is recognized in the relevant IEC standard. Such means shall be insulated from live parts by double or reinforced insulation. The means for functional earthing shall have a distinctive marking from the means for protective earthing and shall not be connected by a conductor identified as PE in accordance with IEC 60445.

NOTE A functional earthing can be used for example for EMC purposes.

7.4.4 Marking

Class II equipment, including equipment complying with 7.4.3.1, shall be marked with the graphical symbol ~~no. 5172~~ of IEC ~~60417-2~~ 60417-5172:2003-02, placed adjacent to the supply information, e.g. on the rating plate, in such a way that it is obvious that the symbol is part of the technical information and can in no way be confused with the manufacturer's name or other identification marks.

Where a class II equipment has a functional earthing terminal, this terminal shall be identified with the graphical symbol IEC 60417-5018: 2011-07.

7.5 Class III equipment

7.5.1 General

Equipment relying on limitation of voltage to ELV values as provision for basic protection and with no provision for fault protection.

7.5.2 Voltages

7.5.2.1 Equipment shall be designed for a maximum nominal voltage not exceeding 50 V a.c. or 120 V d.c. (ripple-free).

NOTE 1 Ripple-free is conventionally defined as an r.m.s. ripple voltage of not more than 10 % of the d.c. component. Maximum values for non-sinusoidal a.c. voltage are under consideration.

NOTE 2 According to Clause 414 of IEC 60364-4-41:2005, class III equipment is accepted only for connection to SELV and PELV systems.

~~NOTE 3~~ Technical committees should determine the maximum permitted rated voltage of their products in accordance with IEC TS 61201 and the specified conditions of use of these products.

7.5.2.2 Internal circuits may operate at any nominal voltage which does not exceed the limits specified in 7.5.2.1.

7.5.2.3 In case of a single fault within the equipment, no steady-state touch voltage which may appear or be generated shall exceed the limits specified in 7.5.2.1.

7.5.3 Protective bonding

Class III equipment shall not be provided with a means of connection for a protective conductor. The equipment may however be provided with means for connection to earth for functional (as distinct from protective) purposes where such a need is recognized in the relevant IEC standard. In any case, provision for the connection of live parts to earth shall not be made in the equipment.

The means for functional earthing shall have a distinctive from that used for a means for protective earthing and shall not be connected by a conductor identified as PE in accordance with IEC 60445.

7.5.4 Marking

The equipment shall be marked with the graphical symbol ~~no. 5180~~ of IEC ~~60417-2~~ 60417-5180:2003-02. This requirement does not apply where the means of connection to the supply is so shaped that it can only mate exclusively with a particularly designed SELV or PELV supply arrangement.

7.6 Touch currents, protective conductor currents~~, leakage currents~~

7.6.1 General

~~NOTE 1~~ Subclause 7.6 is applicable only to low-voltage installations, systems and equipment.

The requirements of 7.6 take into account equipment intended to be supplied by plug and socket-outlet systems, or by a permanent connection, or the case of stationary equipment.

NOTE The effects of leakage current are currently not considered in this standard.

7.6.2 Touch currents

Measures shall be taken so that when accessible parts are touched under normal condition, ~~do not give rise to hazards as indicated in the IEC 60479 series~~ the touch current does not exceed the threshold of perception as indicated in IEC TS 60479-1. The touch currents shall be measured according to IEC 60990. Where additional touch current is allowed under fault conditions, product committees shall specifically identify in their standards the conditions and the additional current allowed.

~~NOTE Subclause 6.2.2 of IEC 60990 deals with touch current measurements for class I equipment in case of loss of the protective conductor.~~

NOTE 1 See Figure 20 of IEC TS 60479-1:2005 for a.c. 50Hz and/or 60Hz and Figure 22 for d.c.

NOTE 2 Values for frequencies up to 10 kHz can be obtained from Figures 1 and 4 of IEC 60479-2:2007. For frequencies above 10 kHz, see 4.4 of IEC 60479-2:2007.

7.6.3 Protective conductor currents

7.6.3.1 General

Measures shall be taken in the installation and in equipment to prevent excessive protective conductor currents impairing safety or normal use of the electrical installation. ~~Compatibility shall be ensured for currents of all frequencies supplied to and produced by the equipment.~~

Technical committees shall determine that the correct operation of protective devices, e.g. RCDs and CBs, is not affected by the protective conductor current generated by products or systems under their scope.

Manufacturers shall make available information on the value and characteristics of the expected protective conductor current under normal operating conditions. For frequencies other than 50 Hz and/or 60 Hz product committees are encouraged to use the lowest practicable values of protective conductor current limits.

7.6.3.2 Requirements for the prevention of excessive protective conductor currents of current-using equipment

~~The requirements for~~ Electrical equipment which causes, under normal ~~operating~~ conditions, a current to flow in ~~its~~ the protective conductor of its supply, shall ~~allow normal use and~~ be compatible with protective provisions. ~~The requirements of 7.5 take into account equipment intended to be supplied by plug and socket-outlet systems, or by a permanent connection, or the case of stationary equipment.~~

7.6.3.3 ~~Maximum a.c.~~ Limits of a.c. components of protective conductor currents of current-using equipment

~~NOTE A protective conductor current measurement method, which takes into account high-frequency components weighted according to IEC 60479-2, is under consideration by TC74.~~

The limit values for protective conductor currents under normal operating conditions as given by Table 4 are applicable to low-voltage current-using equipment supplied at rated frequencies up to 1 kHz.

Table 4 – Maximum protective conductor current for frequencies up to 1 kHz

Rated current of current-using equipment a.c.	Maximum protective conductor current for frequencies up to 1 kHz
$0 < I \leq 2$ A	1 mA
2 A $< I \leq 20$ A	0,5 mA/A
$I > 20$ A	10 mA

For current-using equipment for permanent connection intended to be connected to a reinforced protective conductor according to 7.6.3.5, product committees should state the maximum values for the protective conductor current, which in no case shall exceed 5 % of the rated input current per phase.

Measurements shall be carried out on equipment as delivered.

~~The following limits are applicable to equipment supplied at rated frequency of 50 Hz or 60 Hz:~~

~~a) Plug-in current using equipment fitted with a single or multiphase plug and socket-outlet system rated up to and including 32 A. Limit values are given in annex B.~~

~~b) Current-using equipment for permanent connection and current using stationary equipment, both without special measures for the protective conductor, or plug-in current using equipment fitted with a single phase or multiphase plug and socket-outlet system, rated more than 32 A. Limit values are given in annex B.~~

~~c) Current-using equipment for permanent connection intended to be connected to a reinforced protective conductor according to 7.5.2.4. Product committees should state the maximum values for the protective conductor current, which in no case shall exceed 5 % of the rated input current per phase.~~

~~However, product committees shall consider that, for protective reasons, residual current devices may be provided in the installation, in which case, the protective conductor current shall be compatible with the protective measures provided. Alternatively a transformer with a separate winding and with at least simple separation, shall be used.~~

7.6.3.4 Limits of d.c. components of protective conductor current

In normal use, a.c. current using equipment shall not generate current with a d.c. component in the protective conductor ~~which could affect the proper functioning of residual current devices or other equipment~~ that exceeds the values in Table 5. This will prevent affecting the proper functioning of protective device(s) or other equipment in the installation.

~~NOTE Requirements related to fault currents with d.c. component are under consideration.~~

Table 5 – Maximum protective conductor current for DC

Rated current of current-using equipment a.c.	Maximum protective conductor current d.c.
$I \leq 2$ A	5 mA
2 A $< I \leq$ 20 A	2,5 mA/A
$I >$ 20 A	50 mA

Pluggable electrical equipment with a rated input ≤ 4 kVA shall be designed to have protective conductor current with a smooth superimposed d.c. current component limited to ≤ 6 mA.

For pluggable electrical equipment with a rated input > 4 kVA and permanently connected electrical equipment independent of the rated input shall contain in the operating manual advice about the protective measure.

In case of d.c. protective conductor currents > 6 mA, suitable protective devices shall be selected, e.g. RCD type B.

7.6.3.5 Provisions in equipment in case of connection to reinforced protective conductor circuits for protective conductor currents exceeding 10 mA

The following shall be provided in the current-using equipment:

– a connecting terminal designed for the connection of a protective conductor, ~~measuring~~ having a cross-sectional area of at least of 10 mm^2 Cu or 16 mm^2 Al; or

– a second terminal designed for the connection of a protective conductor of the same cross-section as that of the normal protective conductor so as to connect a second protective conductor to the current-using equipment.

NOTE For requirements for reinforced protective conductors, see 543.7 of IEC 60364-5-54:2011.

7.6.3.6 Information

For equipment intended for permanent connection with reinforced protective conductor, the value of the protective conductor current shall be provided by the manufacturer in his documentation and indication shall be given in the instructions for installation that the equipment shall be installed as described in 7.6.4.2.

7.6.4 Other requirements

7.6.4.1 Signalling systems

~~The use of any active conductor, together with the protective conductor as return path for signalling, is not allowed in the electrical installation of buildings.~~ The use of a protective conductor of an electrical installation for signalling is not allowed.

7.6.4.2 Reinforced protective conductor circuits in installations for protective conductor currents exceeding 10 mA

For current-using equipment intended for permanent connection and having a protective conductor current higher than 10 mA, provision shall be made for a secure and reliable connection with earth such as described in IEC 60364-5-54.

7.6.5 Other effects

Muscular contractions and thermal effects caused by current passing through the human body or livestock and effects of discharge of electrostatic charges may also but not generally lead to hazardous situations.

Technical committees shall take into consideration

– that persons or livestock could become energized by currents of values as described in 4.5.1 resulting from contact with metal parts. It might be necessary to specify additional precautions to prevent the users from experiencing involuntary muscular contractions.
– that persons or livestock could be subjected to values of touch current and charge liable to be hazardous or perceptible (see 4.6.3).
– that due to the effect of currents as described in 4.6.4 flowing in the human body or livestock for more than a few seconds, deep seated burns, and other internal injuries (e.g. kidney failure), could occur. Surface burns may also arise.

7.7 Safety and boundary clearances and ~~warning labels~~ hazard marking for high-voltage installations

The design of the installation shall be such as to restrict access to danger zones. For skilled and instructed persons the need for operational and maintenance access shall be taken into account. Where safety distances cannot be achieved, permanent protective facilities shall be installed. Values shall be specified by technical committee(s) for

– barrier clearances,
– obstacle clearances,
– external fences and access doors,
– minimum height and distance from access areas,
– clearances to buildings.

~~Warning labels~~ Hazard markings shall be prominently displayed on all access doors, fences, protective barriers and overhead line poles and towers, etc.

7.8 Functional earthing

Equipment may be provided with means for connection to earth for functional (as distinct from protective) purposes only where such a need is recognized in the relevant IEC standard (e.g. for EMC purposes). Such means shall be

– insulated from live parts, and

– insulated from exposed conductive parts except where exposed conductive parts are connected to a protective bonding terminal, e.g. in case of PELV equipment.

The means for functional earthing shall have a marking or other identification in accordance with IEC 60445.

8 Special operating and servicing conditions

8.1 General

~~NOTE~~ Detailed requirements for operation of electrical installations, e.g.

– live working;

– de-energized working;

– working close to live parts

are subjects for consideration by appropriate technical committees.

8.2 Devices to be operated manually and components intended to be replaced manually

8.2.1 General

NOTE 1 Examples include:

– devices which need to be reset (e.g. circuit-breakers, overcurrent/overvoltage/undervoltage devices);

– replaceable components (e.g. lamps, fuselinks)

for (re)establishing the function of the installation, system or equipment. Subclause 8.2.2 also applies to access for user maintenance.

NOTE 2 For the purpose of this standard, "manually" means "by hand, with or without a tool".

8.2.2 Devices to be operated or components intended to be replaced by ordinary persons in low-voltage installations, systems and equipment

8.2.2.1 General

Protection against any contact with hazardous-live-parts shall be maintained when operating devices or when replacing components.

NOTE It is recognized that certain lamp-holders and fuse-holders, complying with existing standards, do not fulfil this requirement when the components are being replaced.

8.2.2.2 Where installations, systems or equipment incorporate devices which require manual operation, or components which require manual replacement, these devices and components shall be located where no hazardous-live-parts are accessible.

8.2.2.3 Where compliance with 8.2.2.2 is not practicable, protection shall be provided by means which ensure isolation from the electrical supply before access is gained.

8.2.3 Devices to be operated or components intended to be replaced by skilled or instructed persons

8.2.3.1 General

Protection against unintentional access to hazardous-live-parts or against unintentionally entering the danger zone shall be provided according to 8.2.3.2 and 8.2.3.3 where either

– there are no protective barriers or enclosures, or

– protective barriers or enclosures are to be removed by skilled or instructed persons to gain access to devices requiring manual operation or to components requiring replacement.

~~NOTE~~ Technical committees may restrict the application of this subclause or impose additional requirements and specify the kind of manual operation for which this method of protection is permitted.

8.2.3.2 Location of devices and components

The equipment shall be so designed and installed that the devices and components are accessible and visible to a person who is in a position where he or she may readily and safely operate the device or replace the component.

~~NOTE~~ Such positions and relevant information to be supplied by the manufacturer should be specified by technical committees, as appropriate.

If the mounting position of equipment may adversely affect the visibility or access to devices or components in such a way as to cause a hazard, then the required mounting position shall be indicated and observed.

In case of the presence of a.c. and d.c. circuits in the same equipment and/or installation, the a.c. and d.c. conductors shall be provided with distinct identification

8.2.3.3 Accessibility and operation

The access path to a device and the space needed for its operation shall be such that protection against unintentional contact with hazardous-live-parts or against unintentionally entering the danger zone is provided by an appropriate distance. The distance shall be specified by the technical committee.

Alternatively, where the access path or space has less than the appropriate distance from hazardous-live-parts, obstacles shall be provided. These obstacles shall provide protection against unintentional contact. The degree of protection shall be not less than IPXXB (also complied with by IP2X) of IEC 60529 from the direction of approach to the device or component, and not less than IPXXA (also complied with by IP1X) of IEC 60529 from other appropriate directions.

8.3 Electrical values after isolation

Where protection relies on isolation of hazardous-live-parts from the supply (e.g. when opening enclosures or removing protective barriers), capacitances shall be automatically discharged so that 5 s after isolation, the limit values of voltage specified in ~~6.5~~ Annex A of IEC TS 61201:2007 will not be exceeded. If this would interfere with proper functioning of the

equipment, a readily visible warning notice shall be provided, indicating the time of discharge to the limit values.

~~NOTE 1~~ For particular conditions (e.g. withdrawal of a plug), technical committees may have to specify a shorter time.

~~NOTE 2~~ After isolating, particularly with high voltages, the following effects should be considered:

– capacitors can have high residual charges;
– inductances, e.g. transformer windings, can have a high trapped charge over a relatively long period of time.

8.4 Devices for isolation

8.4.1 General

Devices suitable for isolation shall effectively isolate the circuit concerned from all live conductors of the supply.

NOTE 1 With regard to low voltage, see also 8.4.2.

The position of the contacts or other means of isolation shall, in the isolated position, be either externally visible or clearly and reliably indicated.

NOTE 2 The indication can be achieved by suitable marking to indicate the isolated and closed positions respectively.

Devices suitable for isolation shall be designed and/or erected to prevent unintentional or unauthorized operation.

NOTE 3 Such operation might be caused for example by mechanical shocks and vibrations.

8.4.2 Devices for isolation for low voltage

Devices suitable for isolation shall effectively isolate the circuit concerned from all live conductors of the supply. However, in TN-S or TN-C-S systems where the supply system conditions are such that the neutral or mid-point conductor can be regarded as being reliably at earth potential, the neutral conductor need not be isolated.

Devices for isolation shall comply with the following two conditions:

a) When in the new, clean and dry condition, with the contacts in the position for isolation, the device shall withstand between the line and load terminals, the impulse withstand voltage given in Table 6.

Table 6 – Minimum impulse withstand voltage of devices for isolation related to the nominal voltage

Nominal voltage of the supply system [a]		Minimum impulse withstand voltage [b]	
V		kV	
Three-phase systems	Single-phase systems with middle point	Overvoltage category III	Overvoltage category IV
	120 – 240	3	5
230/400, 277/480		5	8
400/690		8	10
1 000		10	15
NOTE 1 For an explanation of the overvoltage categories, see 4.3.3.2 of IEC 60664-1:2007. NOTE 2 The impulse withstand voltages are referred to an altitude of 2 000 m. NOTE 3 The values of 100/200V, 50Hz or 60Hz are also used in some countries.			
[a] According to IEC 60038. [b] Equipment of overvoltage category II and I are not applicable for isolation.			

b) The leakage current across open poles shall under no circumstances exceed
   - 0,5 mA per pole in the new, clean and dry condition, and
   - 6 mA per pole, at the end of the conventional service life of the device,

   when tested across the terminals of each pole with a test voltage value equal to 110 % of the voltage between line to neutral corresponding to the rated voltage of equipment, when the starpoint or midpoint of the supply is connected to earth. In all other cases the test voltage value shall be equal to 110 % of the line-to-line voltage of the supply system.

   In the case of d.c. testing, the value of the d.c. voltage shall be the same as the r.m.s. value of the a.c. test voltage.

Tests to verify this requirement may be specified by the relevant technical committee.

8.4.3 Devices for isolation for high voltage

8.4.3.1 General

Every isolating device shall be suitable for the assigned purpose.

All general requirements, e.g. earthing arrangements and if necessary the special requirements of the location, e.g. altitude, shall be stated and taken into consideration.

All isolated parts of the main circuit to which access is required or provided shall be capable of being earthed prior to becoming accessible. This requirement does not necessarily apply to removable parts that become accessible after being separated from the installation.

The corresponding specifications for the assigned equipment shall be designed taking into account the network configuration, the local particular conditions and the experiences of operation and maintenance.

It shall be taken into consideration that the expected electrical stresses are not only those found in normal operation, but also additional stresses, for example in case of a short-circuit fault.

Lightning and switching overvoltages shall be also taken into consideration.

Mechanical, climatic and other special stresses which belong to external influences at the site of installation shall be considered during the design process of the equipment.

NOTE Besides these stresses, it is important to pay attention to IEC 60071-1, insulation coordination, by the selection of a suitable switching device.

To avoid unintentional operation, a facility for locking of the isolating device for safety reasons shall be available in the "on" and "off" position.

For the construction or installation of devices for isolation it should be taken into consideration that electric arcs or hot ionizing gases may be generated when switching off. Therefore equipment should be designed or installed in such a way that ionized gas released during switching does not result in damage to the equipment or in danger to operating personnel. This is valid also if there is a secondary flashover by ionization to parts which are not live parts.

8.4.3.2 Characteristics of devices for isolation

Devices for isolation shall comply with the performances defined for longitudinal insulation. That is satisfied when the isolating distance has the dielectric performances specified in IEC 62271-102 for that purpose.

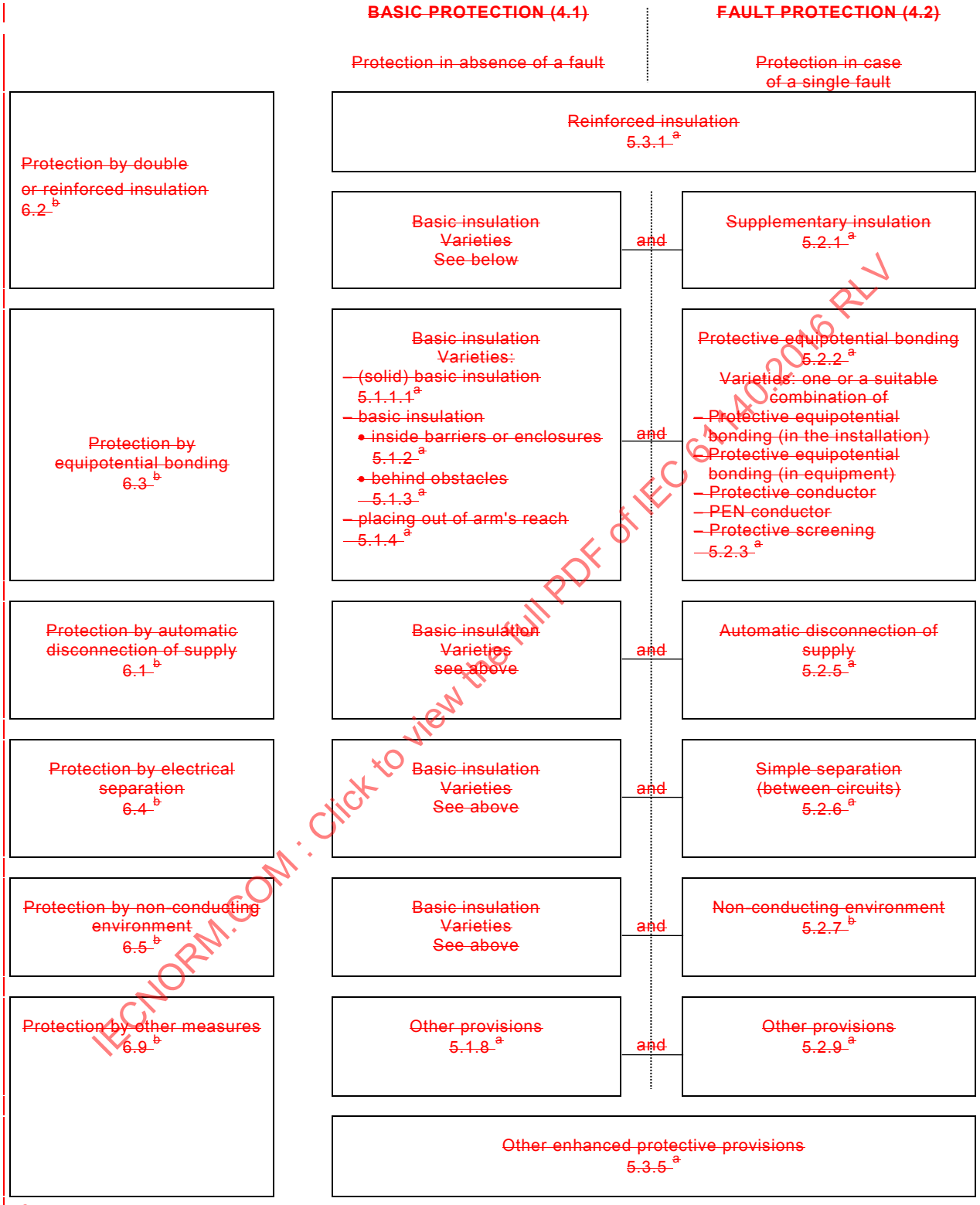
For safety reasons, devices for isolation shall be designed so that any earth leakage current which may flow from one contact to the terminal on the other side of the isolator is limited to an acceptable level. This safety requirement is fulfilled if this leakage current is reliably dissipated to earth.

Annex A
(informative)

Survey of protective measures as implemented by protective provisions

NOTE ~~It should be noted that~~ Not all of the protective provisions are applicable to both low-voltage and high-voltage.

Figure A.1 shows the relationship between protective measures and their respective provisions for basic protection and fault protection.



a Subclause numbers for protective provisions (elements of protective measures).

b Subclause numbers for protective measures.

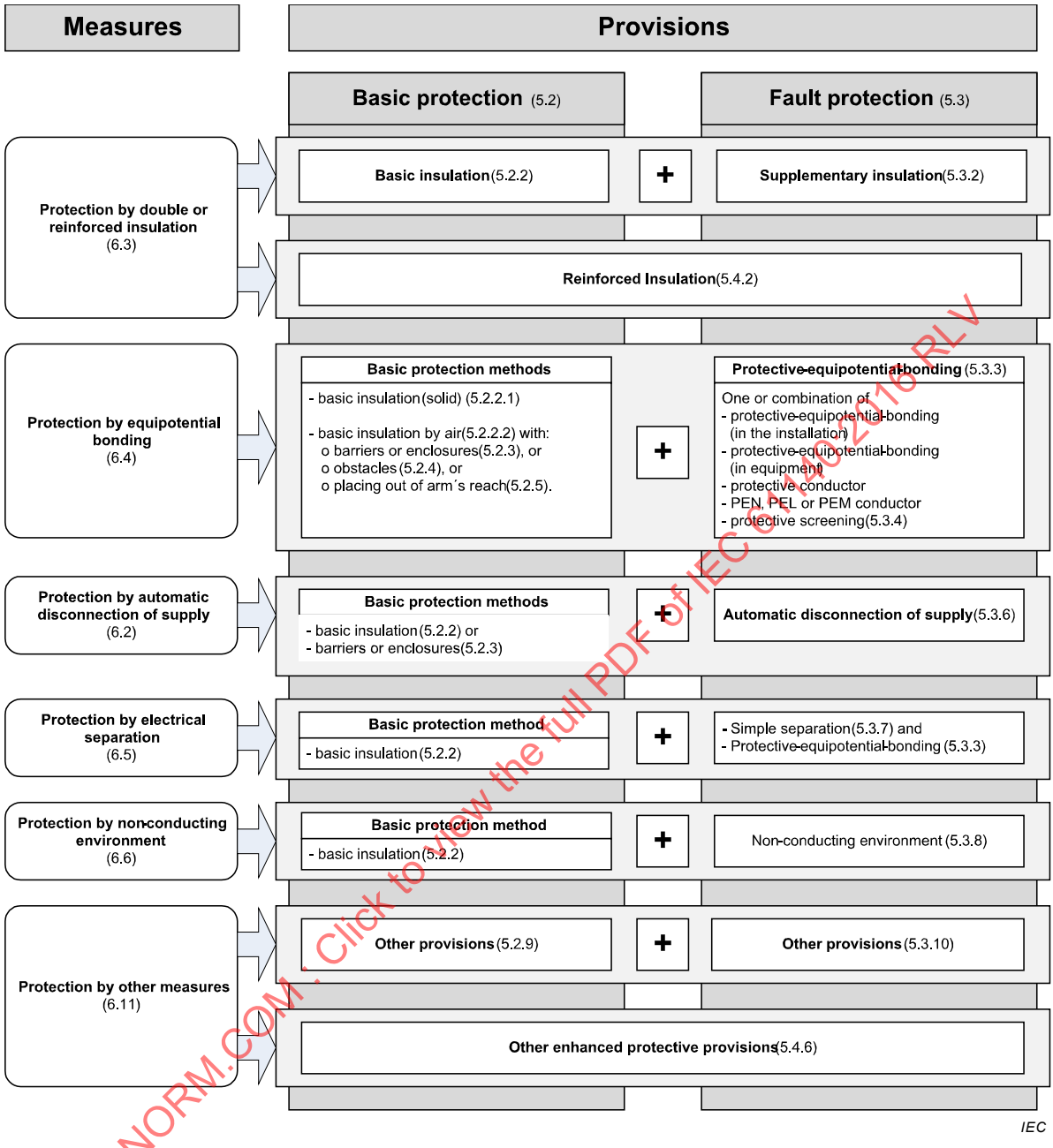
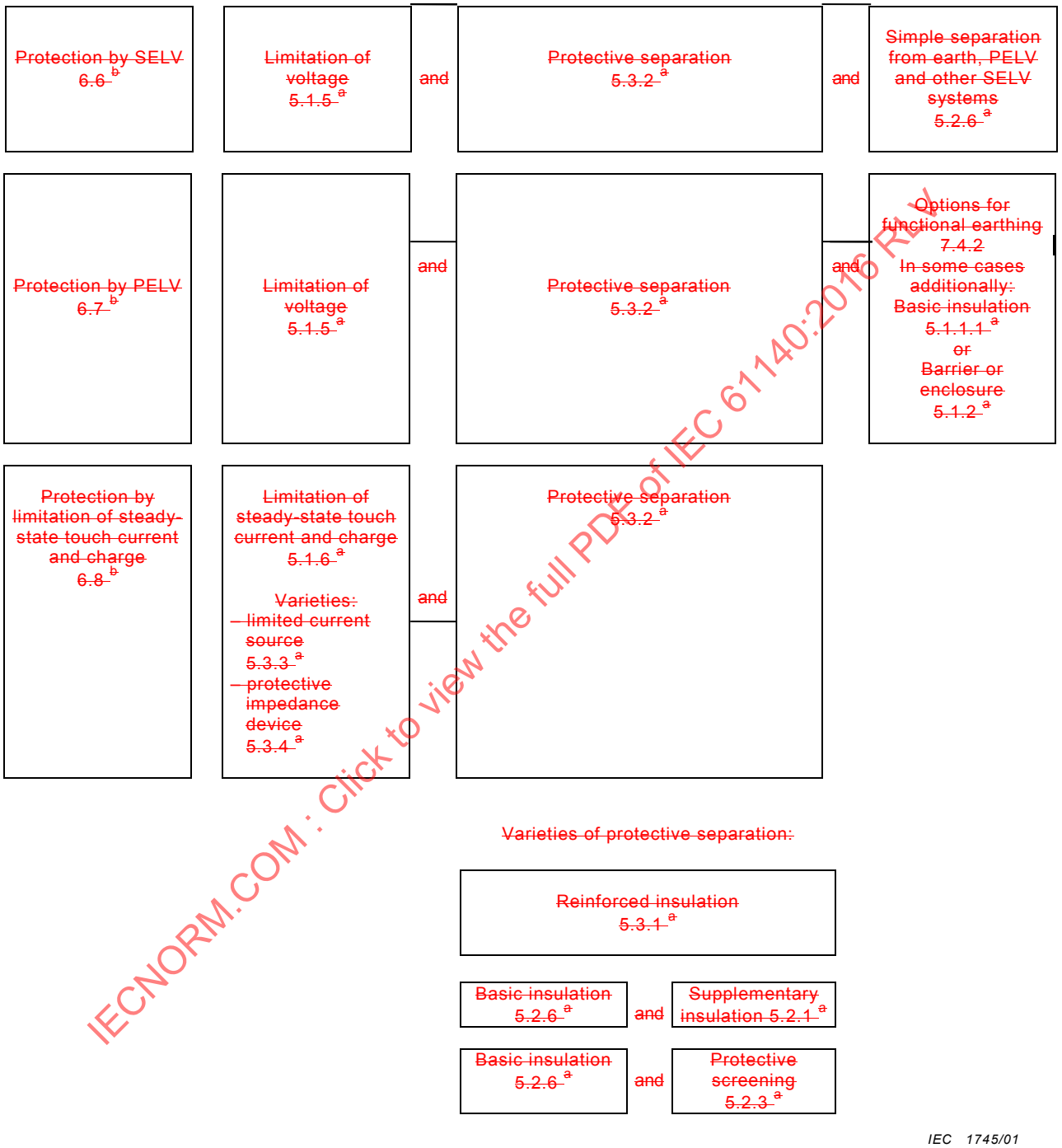


Figure A.1 – Protective measures with basic and fault protection

Figure A.2 shows the relationship between protective measures with limited values of electrical quantities and their respective provisions



a Subclause numbers for protective provisions (elements of protective measures).

b Subclause numbers for protective measures.

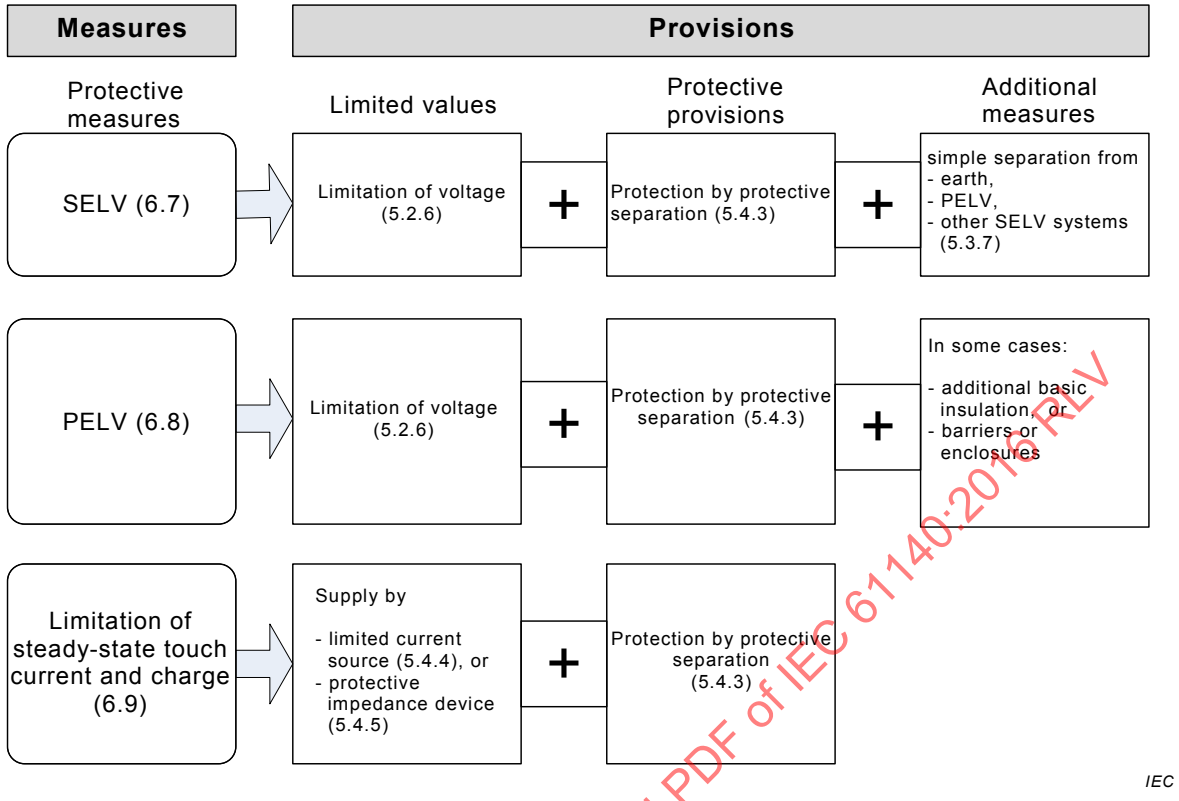


Figure A.2 – Protective measures with limited values of electrical quantities

Figure A.3 shows the relationship between protective measures for additional protection and their respective provisions

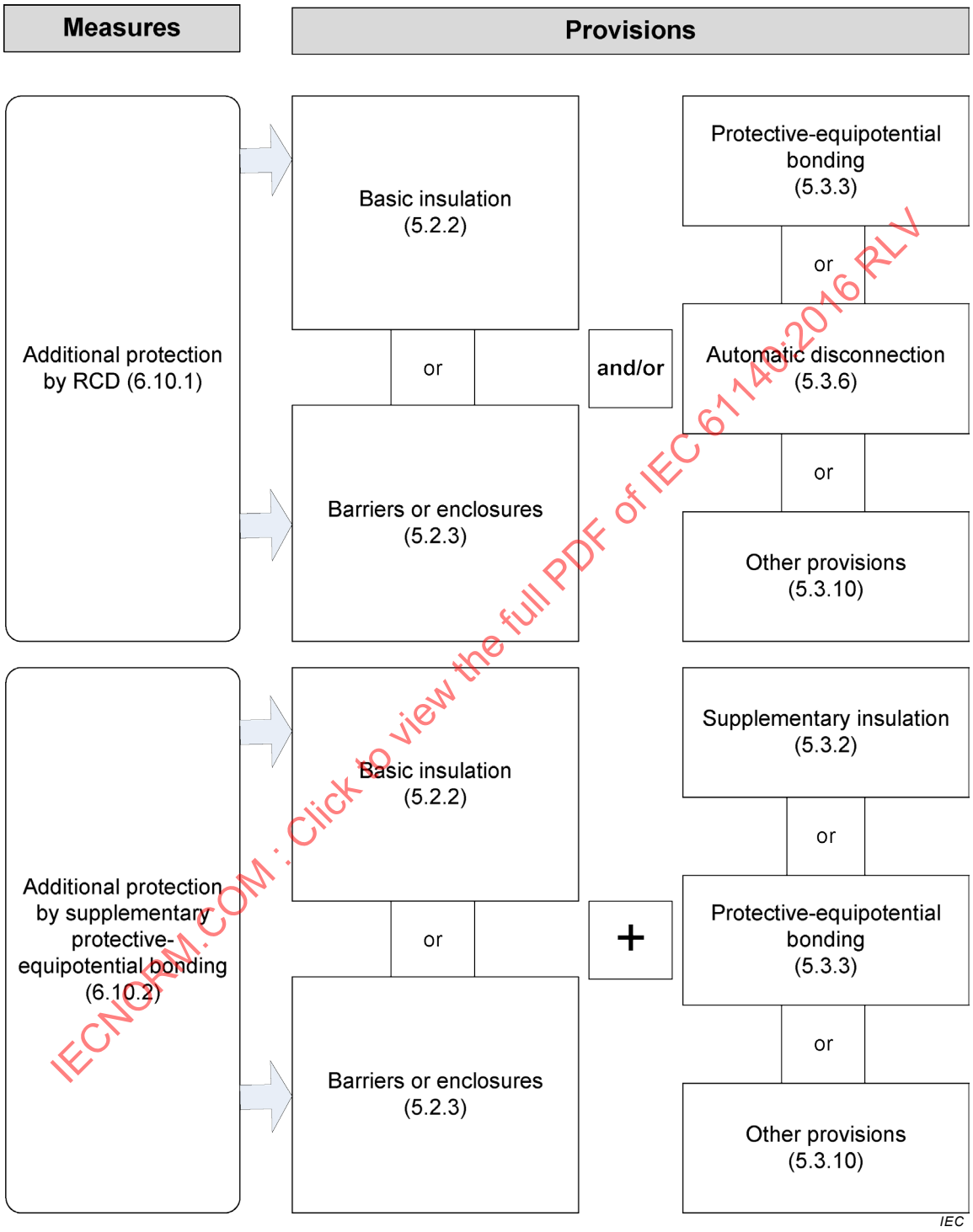


Figure A.3 – Protective measure: additional protection (in addition to basic and/or fault protection)

Annex B
(informative)

Values of maximum a.c. limits of protective conductor currents for cases 7.5.2.2 a) and 7.5.2.2 b)

These values are for consideration by product committees in order to prevent excessive protective conductor currents and to provide co-ordination of electrical equipment and of protective measures within an electrical installation.

Product committees are encouraged to use the lowest practical values of protective conductor current limits.

Product committees should be aware that adoption of limits not exceeding the values below may avoid unwanted tripping of residual current devices in most cases.

Values for 7.5.2.2 a):

Values for plug-in, current-using equipment fitted with a single-phase or multiphase plug and socket-outlet system, rated up to and including 32 A:

Equipment rated current	Maximum protective conductor current
≤4 A	2 mA
>4 A but ≤10 A	0,5 mA/A
>10 A	5 mA

Values for 7.5.2.2 b):

Values for current-using equipment for permanent connection and current-using stationary equipment, both without special measures for the protective conductor, or plug-in, current-using equipment fitted with a single-phase or multiphase plug and socket-outlet system, rated more than 32 A:

Equipment rated current	Maximum protective conductor current
≤7 A	3,5 mA
>7 A but ≤20 A	0,5 mA/A
>20 A	10 mA

Annex B
(informative)

Index of ~~definition~~ terms

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Annex C
(informative)

List of notes concerning certain countries

Country	Clause N°	Nature (permanent or less permanent according to IEC Directives)	Rationale (detailed justification for the requested country note)	Wording
PT	3.1.1			In Portugal for low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact.
PT	3.1.2			In Portugal for low-voltage installations, systems and equipment fault protection generally corresponds to protection against indirect contact.
AT	6.5	permanent	long practical experiences and physical facts	– In Austria, in case of using a transformer as source for protection by electrical separation a safety isolating transformer complying with IEC 61558-2-6 is required. – In Austria, the protective-equipotential-bonding system needs not to be earthed. Under certain conditions, an intentional earthing of the interconnecting conductor or the exposed-conductive-parts of the current-using equipment is allowed.
IT	7.2			In Italy class 0 shall not be used for the design and manufacture of equipments.
US	7.3.5.1			In the USA, solid colour green is also used to indicate the terminal for connection to the protective conductor.

Bibliography

IEC 60050-195:1998, *International Electrotechnical Vocabulary – Part 195: Earthing and protection against electric shock*
IEC 60050-195:1998/AMD1:2001

IEC 60050-351, *International Electrotechnical Vocabulary – Part 351: Control technology*

IEC 60050-826:2004, *International Electrotechnical Vocabulary – Part 826: Electrical installations*

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

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-6:2006, *Low-voltage electrical installations – Part 6: Verification*

IEC 60479 (all parts), *Effects of current on human beings and livestock*

IEC TS 60479-2:2007, *Effects of current on human beings and livestock – Part 2: Special aspects*

IEC 60601-1, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

Additional non-cited references

IEC 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory*

IEC 61936-1, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC TS 61936-2, *Power installations exceeding 1 kV a.c. and 1,5 kV d.c. – Part 2: d.c.*

IEC 61140

Edition 4.0 2016-01

INTERNATIONAL STANDARD

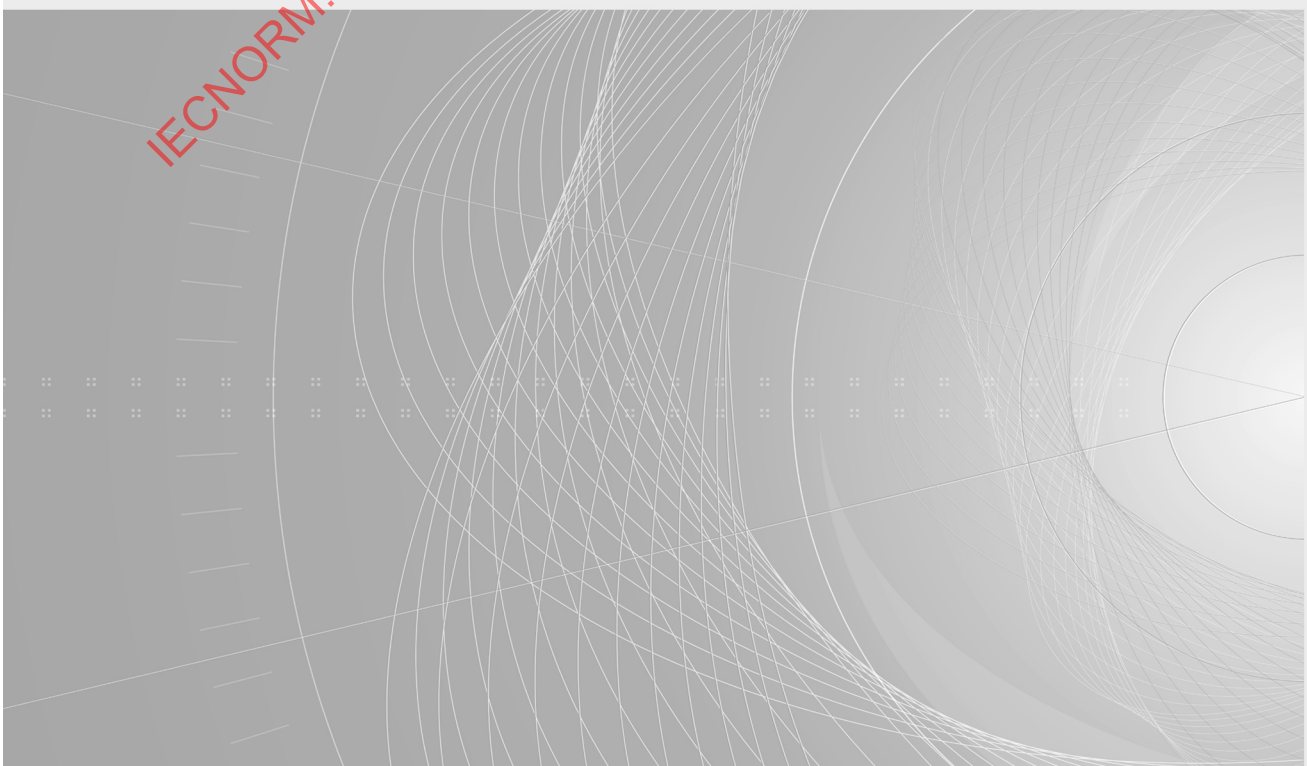
NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Protection against electric shock – Common aspects for installations and equipment

Protection contre les chocs électriques – Aspects communs aux installations et aux matériels



IEC 61140:2016-01(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATION AND EQUIPMENT

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61140 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition cancels and replaces the third edition published in 2001 and Amendment 1:2004. This edition constitutes a technical revision.

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

a) Introduction of the content of IEC 60449
b) Better distinction between provisions and measures
c) Consideration of effects other than ventricular fibrillation
d) Additional protection was introduced
e) ELV defined as part of LV
f) Devices suitable for isolation required for automatic disconnection of supply (LV)

g) Requirements relating to current in the protective conductor were moved to the main body of the standard

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

FDIS	Report on voting
64/2076/FDIS	64/2091/RVD

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

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

It has the status of a basic safety publication in accordance with IEC Guide 104.

The reader's attention is drawn to the fact that Annex C lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this standard.

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

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

PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATIONS AND EQUIPMENT

1 Scope

This International Standard is a basic safety publication primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

It is not intended to be used as a stand-alone standard.

According to IEC Guide 104, technical committees, when preparing, amending, or revising their publications, are required to make use of any basic safety publication such as IEC 61140.

This International Standard applies to the protection of persons and livestock against electric shock. The intent is to give fundamental principles and requirements which are common to electrical installations, systems and equipment or necessary for their coordination, without limitations with regard to the magnitude of the voltage or current, or the type of current, and for frequencies up to 1 000 Hz.

Some clauses in this standard refer to low-voltage and high-voltage systems, installations and equipment. For the purposes of this standard, low-voltage is any rated voltage up to and including 1 000 V a.c. or 1 500 V d.c.. High voltage is any rated voltage exceeding 1 000 V a.c. or 1 500 V d.c..

It should be noted that, for an efficient design and selection of protective measures, the type of voltage that may occur and its waveform needs to be considered, i.e. a.c. or d.c. voltage, sinusoidal, transient, phase controlled, superimposed d.c., as well as a possible mixture of these forms. The installations or equipment may influence the waveform of the voltage, e.g. by inverters or converters. The currents flowing under normal operating conditions and under fault conditions depend on the described voltage.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60068 (all parts), *Environmental testing*

IEC 60071-1, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60071-2, *Insulation coordination – Part 2: Application guide*

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60417, *Graphical symbols for use on equipment*
(available at http://www.graphical-symbols.info/equipment)

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC TS 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TR 60479-5, *Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects*

IEC 60529, *Degrees of protection provided by enclosure (IP Code)*

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

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60721 (all parts), *Classification of environmental conditions*

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

IEC TS 61201:2007, *Use of conventional touch voltage limits – Application guide*

IEC 62271-102, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

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

ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

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

NOTE An index of definitions is given in Annex B.

3.1
electric shock
physiological effect resulting from an electric current through a human body or livestock

Note 1 to entry: Physiological effects include, for example, perception, muscular contractions and tetany, difficulty in breathing, disturbances of heart function, immobilization, cardiac arrest, breathing arrest, burns or other cellular damage.

Note 2 to entry: Physiological effects resulting from EMF are not considered in this standard.

[SOURCE: IEC 60050-195:1998, 195-01-04, modified – "through a human body or livestock" replaces "passing through a human or animal body"; addition of 2 Notes to entry]

3.1.1
basic protection
protection against electric shock under fault-free conditions

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

3.1.2
fault protection
protection against electric shock under single fault conditions

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-02]

3.1.3
additional protection
protection against electric shock in addition to basic protection and/or fault protection

[SOURCE:IEC 60050-826:2004, 826-12-07, modified – "protection against electric shock" replaces "protective measure"]

3.1.4
single fault condition
condition in which one means for protection against electric shock is defective or one fault is present which could cause a hazard

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

3.2
electric circuit
arrangement of devices or media through which electric current can flow

Note 1 to entry: See also IEC 60050-826:2004, 826-14-01 for electrical installations of buildings.

3.3
electrical equipment
item used for such purposes as generation, conversion, transmission, distribution or utilization of electric energy, such as electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems, current-using equipment

[SOURCE: IEC 60050-826:2004, 826-16-01]

3.4
live part
conductive part intended to be energized in 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 concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19, modified – "…normal conditions, including a neutral conductor or mid-point conductor" replaces "normal operation, including a neutral conductor.."]

3.5
hazardous-live-part
live part which, under certain conditions, can give a harmful electric shock

Note 1 to entry: In case of high voltage, a hazardous voltage may be present on the surface of solid insulation. In such a case the surface is considered to be a hazardous-live-part.

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

3.6
exposed-conductive-part
conductive part of equipment, 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 electrical equipment which can become live only 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]

3.7
extraneous-conductive-part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-195:1998, 195-06-11]

3.8
touch voltage

3.8.1
(effective) touch voltage
voltage between conductive parts when touched simultaneously by a human or livestock

Note 1 to entry: The value of the effective touch voltage may be appreciably influenced by the impedance of the person or the livestock in electric contact with these conductive parts.

[SOURCE: IEC 60050-195:1998, 195-05-11, modified – “by a human or livestock” replaces “by a person or an animal”]

3.8.2
prospective touch voltage
voltage between simultaneously accessible conductive parts when those conductive parts are not being touched, by a human or livestock

[SOURCE: IEC 60050-195:1998, 195-05-09, modified – “by a human or livestock” replaces “by a person or an animal”]

3.9
touch current
electric current passing through a human body or through livestock when it touches one or more accessible parts of an installation or of equipment

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-05-21, modified – “through livestock” replaces “through an animal body”]

3.10
insulation
set of properties which characterize the ability of an insulation to provide its function

Note 1 to entry: Examples of relevant properties are: resistance, breakdown voltage.

Note 2 to entry: Insulation can be a solid, a liquid or a gas (e.g. air), or any combination.

[SOURCE: IEC 60050-151:2001, 151-15-42, modified – Note 2 to entry added]

3.10.1
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 60050-195:1998, 195-06-06]

3.10.2
supplementary insulation
independent insulation applied in addition to basic insulation, for fault protection

[SOURCE: IEC 60050-195:1998, 195-06-07]

3.10.3
double insulation
insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.10.4
reinforced insulation
insulation of hazardous-live-parts which provides 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.

[SOURCE: IEC 60050-195:1998, 195-06-09, modified – ..provides "a degree" of …, deleted]

3.11
non-conducting environment
provision whereby a human or livestock touching an exposed-conductive-part that has become hazardous-live is protected by the high impedance of his environment (e.g. insulating walls and floors) and by the absence of earthed conductive parts

[SOURCE: IEC 60050-195:1998, 195-06-21, modified – "animal" replaced by "livestock"]

3.12
(electrically) protective obstacle
part preventing unintentional contact by a human or livestock with a live part, but not preventing such contact by deliberate action

[SOURCE: IEC 60050-195:1998, 195-06-16, modified – "direct contact" replaced by "contact" and "by a human or livestock with a live part".. introduced]

3.13
(electrically) protective barrier
part providing protection against contact by a human or livestock with a live part from any usual direction of access

[SOURCE: IEC 60050-195:1998, 195-06-15, modified – "direct contact" replaced by "contact" and "by a human or livestock with a live part" … introduced]

3.14
(electrically) protective enclosure
electrical enclosure surrounding internal parts of equipment to prevent access to a live-part from any direction

Note 1 to entry: In addition, an enclosure generally provides protection against internal or external influences, e.g. ingress of dust or water or prevention of mechanical damage.

[SOURCE: IEC 60050-195:1998, 195-06-14, modified – "hazardous live-parts" replaced by "a live-part" and Note 1 to entry added]

3.15
arm's reach
zone of accessibility to touch extending from any point on a surface where persons usually stand or move about to the limits which a person can reach with the hand, in any direction, without assistance

[SOURCE: IEC 60050-195:1998, 195-06-12]

3.16
equipotential bonding
provision of electric connections between conductive parts intended to achieve equipotentiality

Note 1 to entry: The effectiveness of the equipotential bonding may depend on the frequency of the current in the bonding.

[SOURCE: IEC 60050-195:1998, 195-01-10, modified – Note 1 to entry added]

3.16.1
protective-equipotential-bonding
equipotential bonding for the purposes of safety (e.g. protection against electric shock)

Note 1 to entry: Functional equipotential bonding is defined in IEC 60050-195:1998, 195-01-16.

[SOURCE: IEC 60050-195:1998, 195-01-15, modified – "(e.g. protection against electric shock)" introduced and Note 1 to entry added]

3.16.2
equipotential bonding terminal
terminal provided on equipment or on a device and intended for the electric connection with the equipotential bonding system

[SOURCE: IEC 60050-195:1998, 195-02-32]

3.16.3
protective bonding terminal
terminal intended for protective-equipotential-bonding purposes

3.16.4
protective conductor
conductor provided for purposes of safety, for example protection against electric shock

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.16.5
PE conductor
protective conductor provided for protective earthing

[SOURCE: IEC 60050-195:1998, 195-02-11, modified – term title changed]

3.16.6
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

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

3.16.7
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]

3.16.8
PEL conductor
conductor combining the functions of both a protective earthing conductor and a line conductor

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

3.16.9
protective bonding conductor
protective conductor provided for protective-equipotential-bonding

[SOURCE: IEC 60050-195:1998, 195-02-10]

3.16.10
line conductor
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]

3.16.11
neutral conductor
conductor electrically connected to the neutral point and capable of contributing to the distribution of electric energy

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

3.17
earth
concept embracing the planet and all its physical matter

3.17.1
earth (verb)
ground (verb) (US)
to make an electrical connection between local earth and a given point in a system, installation or equipment

Note 1 to entry: The connection to local earth may be:

– intentional; or
– unintentional; or
– accidental

and may be permanent or temporary.

3.17.2
reference earth
reference ground (US)
part of the Earth considered as conductive, the electric potential of which is conventionally taken as zero, being outside the zone of influence of any earthing arrangement

[SOURCE: IEC 60050-195:1998, 195-01-01, modified – Note deleted]

3.17.3
(local) earth
(local) ground (US)
part of the Earth which is in electric contact with an earth electrode and the electric potential of which is not necessarily equal to zero

[SOURCE: IEC 60050-195:1998, 195-01-03]

3.17.4
earth electrode
ground electrode (US)
conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with the Earth

[SOURCE: IEC 60050-195:1998, 195-02-01]

3.17.5
earthing conductor
grounding conductor (US)
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

[SOURCE: IEC 60050-195:1998, 195-02-03]

3.17.6
earthing arrangement
grounding arrangement (US)
all the electric connections and devices involved in the earthing of a system, an installation and equipment

Note 1 to entry: This could be a locally limited arrangement of interconnected earth electrodes on the high-voltage side.

[SOURCE: IEC 60050-195:1998, 195-02-20, modified – Note 1 to entry added]

3.17.7
protective earthing
protective grounding (US)
earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11]

3.17.8
functional earthing
functional grounding (US)
earthing a point or points in a system or in an installation or in equipment for purposes other than electrical safety

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.18
automatic disconnection of supply
interruption of one or more of the line conductors effected by the automatic operation of a protective device in the event of a fault

Note 1 to entry: This does not necessarily mean an interruption in all conductors of the supply system.

[SOURCE: IEC 60050-195:1998, 195-04-10, modified – "in the event of a fault" replaces "in case of a fault" and Note 1 to entry added]

3.19
enhanced protective provision
protective provision having a reliability of protection not less than that provided by two independent protective provisions

3.20
(conductive) screen
(conductive) shield (US)
conductive part that encloses or separates electric circuits and/or conductors

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-02-38]

3.21
(electrically) protective screen
(electrically) protective shield (US)
conductive screen (shield) used to separate an electric circuit and/or conductors from hazardous-live-parts

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-17]

3.22
(electrically) protective screening
(electrically) protective shielding (US)
separation of electric circuits or conductors from hazardous-live-parts by an electrically protective screen connected to the protective-equipotential-bonding system and intended to provide protection against electric shock

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-18]

3.23
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]

3.24
(electrically) protective separation
separation of one electric circuit from another by means of:

– double insulation; or
– basic insulation and electrically protective screening (shielding); or
– reinforced insulation

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-19]

3.25
(electrical) separation
protective measure in which hazardous-live-parts are insulated from all other electric circuits and parts, from local earth and from touch

[SOURCE: IEC 60050-826:2004, 826-12-27]

3.26
extra-low voltage
ELV
voltage not exceeding the maximum value of the prospective touch voltage which is permitted to be maintained indefinitely under specified conditions of external influences

3.26.1
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 1 to entry: SELV is the abbreviation for safety extra-low voltage.

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

3.26.2
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]

3.27
protection by limitation of steady-state touch current and electric charge
protection against electric shock by electric circuit or equipment design so that under normal and fault conditions the steady-state current and electric charge are limited to below a hazardous level

[SOURCE: IEC 60050-826:2004, 826-12-34, modified – "steady-state current" replaced by "steady-state touch current"]

3.28
limited-current-source
device supplying electrical energy in an electric circuit

– with protective-separation from hazardous-live-parts, and
– which ensures that the steady-state touch current and charge are limited to non-hazardous levels, under normal and fault conditions

3.29
protective impedance device
component or assembly of components whose impedance and construction limit steady-state-touch current and electric charge to non-hazardous levels

[SOURCE: IEC 60050-826:2004, 826-12-35, modified – “are intended to” limit … deleted]

3.30
(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 60050-195:1998/AMD1:2001, 195-04-01]

3.31
(electrically) instructed person
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/AMD1:2001, 195-04-02]

3.32
ordinary person
person who is neither a skilled person nor an instructed person

[SOURCE: IEC 60050-195:1998, 195-04-03]

3.33
step voltage
voltage between two points on the Earth's surface that are 1 m distant from each other

Note 1 to entry: 1 m is considered to be the stride length of a person.

[SOURCE: IEC 60050-195:1998, 195-05-12, modified – ", which is considered to be the stride length of a person" …deleted and Note 1 to entry added]

3.34
potential grading
control of the earth potential, especially the earth surface potential, by means of earth electrodes

3.35
danger zone
in the case of high voltage, area limited by the minimum clearance around hazardous-live-parts without complete protection

Note 1 to entry: Entering the danger zone is considered the same as touching hazardous-live-parts.

3.36
leakage current
electric current in an unintended conductive path under normal conditions

[SOURCE: IEC 60050-195:1998, 195-05-15, modified – "unintended" replaces "unwanted"]

3.37
stationary equipment
fixed equipment or electric equipment not provided with a carrying handle and having such a mass that it cannot easily be moved

Note 1 to entry: The value of this mass is minimum 18 kg in IEC standards relating to household appliances.

[SOURCE: IEC 60050-826:2004, 826-16-06, modified – "minimum" added to Note 1 to entry]

3.38
protective conductor current
electric current appearing in a protective conductor, such as leakage current or electric current resulting from an insulation fault

[SOURCE: IEC 60050-826:2004, 826-11-21]

3.39
system
set of interrelated elements considered in a defined context as a whole and separated from their environment

[SOURCE: IEC 60050-351:2013, 351-42-08, modified – Notes deleted]

3.40
(electrical) installation
assembly of associated electric equipment having coordinated characteristics to fulfil specific purposes

[SOURCE: IEC 60050-826:2004, 826-10-01]

3.41
isolation
function intended to disconnect and maintain for reasons of safety adequate clearance from every source of electric energy

3.42
impulse withstand voltage
peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified conditions

3.43
electric burn
burning of the skin or an organ caused by an electric current along its surface or through it

[SOURCE: IEC 60050-195:1998, 195-03-01]

3.44
protective provision
independent provision intended to protect against electric shock under specified conditions

Note 1 to entry: The provision may be a means or technique or device or process.

3.45
protective measure
appropriate combination of protective provisions for protection against electric shock

4 Fundamental rule of protection against electric shock

4.1 General

Electric shock is defined as the physiological effect resulting from an electric current passing through a human body or livestock. The physiological effect might be harmful (such as ventricular fibrillation, burns, asphyxiation), see 4.2 to 4.5, or non-harmful (such as muscular reaction, perception), see 4.6.

Hazardous-live-parts shall not be accessible and accessible-conductive-parts shall not be hazardous live either:

– under normal conditions (operation in intended use, see 3.6 of ISO/IEC Guide 51:2014, and absence of a fault); or

– under single-fault conditions.

NOTE The accessibility rules for ordinary persons can differ from those for skilled or instructed persons and can also vary for different products and locations.

For high-voltage installations, systems and equipment, entering the danger zone is considered the same as touching hazardous-live-part.

Protection under normal conditions (see 4.2) is provided by basic protection. Protection under single-fault conditions (see 4.3) is provided by fault protection. Additional protection is specified as part of a protective measure (see 4.4), where applicable.

Enhanced protective provisions (see 4.3.3) provide protection under both normal and single-fault conditions.

4.2 Normal conditions

To meet the fundamental rule for protection against electric shock under normal conditions, basic protection, as specified in this standard, is necessary.

The requirements for provisions for basic protection are given in 5.2.

In order to provide requirements for installations and for equipment, the following bands are specified:

- High voltage (HV)

  where protection against electric shock is ensured by special measures, in particular earthing arrangements.

- Low voltage (LV)

  where protection against electric shock is ensured by basic protection and in general also fault protection.

  Extra-low-voltage (ELV) is a part of the LV band.

  When ELV is applied, fault protection may not be needed, and under certain conditions basic protection is provided by limitation of voltage. These conditions include contact area, moisture, voltage, current, and others defined for particular applications.

Table 1 specifies the different voltage limits for the above mentioned bands.

The values in Table 1 are based on the following conditions:

- a.c. systems:
  - for earthed systems by the r.m.s. values of the voltages between line and earth and between lines;
  - for isolated or not effectively earthed systems, by the r.m.s. value of the voltage between lines.
- d.c. systems:
  - for earthed systems by values of the voltages between line and earth and between lines;
  - for isolated or not effectively earthed systems, by the value of the voltage between lines.

Table 1 – Limits for voltage bands

Voltage band		a.c.	d.c.
HV		> 1 000 V	> 1 500 V
LV		≤ 1 000 V	≤ 1 500 V
	ELV	≤ 50 V	≤ 120 V

The upper limit of ELV of 120 V d.c. has for many years been agreed by convention. However, different environmental and contact situations as described in IEC TS 60479-1 cause different values of touch current, for a given voltage. Also the waveform of the current and the path taken through the body strongly influences the level of danger. Therefore, technical committees are requested to consider very carefully whether an ELV value less than 120 V d.c. might be necessary for their specific standard.

4.3 Single-fault conditions

4.3.1 General

Single faults shall be considered, if they would

– cause an accessible, non-hazardous-live-part to become a hazardous-live-part (e.g. due to failure to limit the steady-state touch current and charge); or

– cause an accessible conductive part which is not live under normal conditions to become a hazardous-live-part (e.g. due to failure of basic insulation to exposed-conductive-parts); or

– cause a hazardous-live-part to become accessible (e.g. by mechanical failure of an enclosure).

To meet the fundamental rule under single-fault conditions, fault protection, and in certain cases additional protection, is necessary. This protection can be achieved by

– a further protective provision, independent of that for basic protection (see 4.3.2), or

– an enhanced protective provision (see 4.3.3) which provides both basic and fault protection,

taking account of all relevant influences.

The requirements for provisions for fault protection are given in 5.3.

4.3.2 Protection by independent protective provisions

Each of the independent protective provisions shall be designed so that a failure is unlikely under conditions specified by the relevant technical committee.

The independent protective provisions shall have no influence on each other such that a failure of one of the protective provisions could impair another.

Simultaneous failure of independent protective provisions is unlikely and need not normally be taken into consideration. Reliance is placed on the unaffected protective provisions remaining effective.

4.3.3 Protection by an enhanced protective provision

The properties of an enhanced protective provision shall be such that the same continued effectiveness of protection as provided by two independent protective provisions is achieved. Requirements for enhanced protective provisions are given in 5.4.

4.4 Additional protection

If the intended use implies an increased inherent risk, e.g. for areas with a low-impedance contact of persons with earth potential, technical committees shall consider the possible need to specify additional protection. Such additional protection may be provided in the installation, in the system or in the equipment.

Requirements for additional protection are given in 5.5.

Single fault conditions resulting in one or multiple subsequent failures shall be considered as a single fault condition.

4.5 Protection against electric burns

Technical committees shall specify measures to protect against electric burns in their standards.

An electric burn can be caused where a current of sufficient density and duration flows through the human body or livestock. Arcs can also cause burns.

The effects can be severe even if only a small part of the body is involved.

NOTE 1 Deep-seated burns and other internal injuries, or surface burns can occur.

NOTE 2 Technical information on electric burns can be found in IEC TS 60479-1 and measurement technique in IEC 60990 for many cases.

4.6 Protection against physiological effects without adverse health effect

4.6.1 General

Technical committees shall consider whether the following effects are to be taken into account in their standards.

Current flowing through a human body without being directly harmful may cause situations which are inconvenient or hazardous (such as results of startle reaction).

This may concern threshold of perception or threshold of pain or heat sensation.

4.6.2 Muscular reaction

Involuntary muscular contractions are likely to occur, when currents through the human body or livestock are flowing in the range of areas AC-2 of the time/current zones, for a.c. 15 Hz to 100 Hz, and in the range of areas DC-2 of the time/current zones, for d.c., according to IEC TS 60479-1.

For alternating current with a frequency not exceeding 100 Hz, or for a direct current with ripple not exceeding 10 %, the touch voltage threshold for reaction shall not exceed the values in Table 2:

Table 2 – Touch voltage thresholds for reaction

Type of reaction	Voltage threshold
Startle reaction	2 V a.c. or 8 V d.c
Muscular reaction	20 V a.c. or 40 V d.c

These values of Table 2 are defined for dry conditions and a contact area of 35 cm^2.

If other environmental conditions, such as salt water wet, water wet or immersed are considered, these values may be reduced, depending also on the current path through the body.

4.6.3 Effects of touch current of discharge of electrostatic charges

Startle reactions are likely to occur when currents resulting from electrostatic discharge are flowing in the human body or livestock.

4.6.4 Thermal effects

Heat sensation can be experienced, when even small values of current are flowing through the human body or livestock. The effect may be more evident at higher frequencies.

Effects such as rise in blood pressure, immobilization, disturbances of formation and conduction of cardiac impulses (including atrial fibrillation and transient rhythm disturbances) may occur.

5 Protective provisions (elements of protective measures)

5.1 General

Subclauses 5.2 to 5.5 give an overview of the different protective provisions. Protective measures result from a suitable combination of them. The structure of typical protective measures is described in Clause 6.

All protective provisions shall be designed and constructed to be effective during the anticipated lifetime of the installation, of the system or of the equipment when used as intended and properly maintained.

The environment shall be taken into account by use of the classification of external influences as described in the IEC 60721 series and for testing in the IEC 60068 series. Attention is particularly drawn to the ambient temperature, climatic conditions, presence of water, mechanical stresses, capability of persons and area of contact of persons or livestock with earth potential.

Technical committees shall take account of the requirements for insulation coordination. For low-voltage installations, systems and equipment these requirements are found in the IEC 60664 series which also gives dimensioning rules for clearances (in air) and creepage distances as well as dimensioning guidance for solid insulation. For high-voltage installations, systems and equipment, the requirements are found in IEC 60071-1 and IEC 60071-2.

5.2 Provisions for basic protection

5.2.1 General

Basic protection shall consist of one or more provisions that, under normal conditions, prevent contact with hazardous-live-parts.

NOTE Paints, varnishes, lacquers and similar products alone are generally not considered to provide adequate insulation for protection against electric shock in normal service.

Subclauses 5.2.2 to 5.2.9 specify some individual provisions for basic protection.

5.2.2 Basic insulation

5.2.2.1 Where solid basic insulation is used, it shall prevent contact with hazardous-live-parts.

In case of high-voltage installations and equipment, a voltage may be present on the surface of solid insulation and further precautions shall be considered.

5.2.2.2 Where basic insulation is provided by air, access to hazardous-live-parts or entering the danger zone shall be prevented by obstacles, protective barriers or enclosures as specified in 5.2.3 and 5.2.4 or by placing out of arm's reach as specified in 5.2.5.

5.2.3 Protective barriers or enclosures

5.2.3.1 Protective barriers or enclosures shall prevent:

– in the case of low-voltage installations and equipment, access to hazardous-live-parts by providing a degree of protection against electric shock of at least IPXXB or IP2X of IEC 60529 and, for readily accessible horizontal top surfaces of protective barriers or enclosures, at least IPXXD or IP4X

– in the case of high-voltage installations and equipment, entering the danger zone by providing a degree of protection of at least IPXXB or IP2X of IEC 60529, and consideration shall be given to providing a degree of protection of at least IPXXD or IP4X for readily accessible horizontal top surfaces of protective barriers or enclosures

NOTE The IP code applies to the enclosures of electrical equipment of rated voltage not exceeding 72,5 kV.

5.2.3.2 Protective barriers or enclosures shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection, taking account of all relevant influences from the environment and from inside the enclosure. They shall be firmly secured in place.

5.2.3.3 Where the design or construction allows for the removal of protective barriers, the opening of enclosures or the removal of parts of enclosures, access to hazardous-live-parts or entering the danger zone shall be possible only

– by the use of a key or tool, or

– after isolation of hazardous-live-parts from the supply circuit where the enclosure would no longer provide protection, restoration of the supply shall become possible only after replacement of protective barriers or parts of enclosures or after the closing of doors, or

– where an intermediate barrier still maintains the required degree of protection, such barrier being removable only by the use of a key or tool.

NOTE See also Clause 8.

5.2.4 Obstacles

5.2.4.1 Obstacles are intended to protect skilled or instructed persons but their use is not permitted for the protection of ordinary persons.

5.2.4.2 During the operation of the installation, system or equipment under special operating and servicing conditions (see Clause 8), obstacles shall prevent:

– in the case of low-voltage installations and equipment, unintentional contact with hazardous-live-parts, or

– in the case of high-voltage installations and equipment, unintentional entering the danger zone.

5.2.4.3 Obstacles may be removable without using a key or tool but shall be so secured as to make unintentional removal unlikely.

5.2.4.4 Where a conductive obstacle is separated from hazardous-live-parts by basic insulation only, it is considered to be an exposed-conductive-part, and measures for fault protection (see Clause 6) shall also be applied.

5.2.5 Placing out of arm's reach

5.2.5.1 Where provisions specified in 5.2.2, 5.2.3, 5.2.4, 5.2.6 and 5.2.7 are found to be not applicable, placing out of arm's reach may be appropriate to prevent

– in the case of low-voltage installations and equipment, unintentional simultaneous access to conductive parts between which a hazardous voltage can exist,

– in the case of high-voltage installations and equipment, unintentional entering into the danger zone.

Details shall be specified by technical committees.

For low-voltage installations, parts that are separated by a distance of more than 2,5 m are normally considered not to be simultaneously accessible. Where access is restricted to skilled or instructed persons, reduced distances may be specified.

5.2.5.2 Where a distance is expected to be reduced by objects which a person uses or holds in the hand, such as a tool or a ladder, technical committees shall specify relevant restrictions, or an appropriate distance between conductive parts between which a hazardous voltage can exist.

5.2.6 Limitation of voltage

Basic protection by the provision of limitation of voltage is fulfilled where both of the following conditions are fulfilled:

a) touch voltage under no circumstances exceeds:
   1) 25 V a.c. r.m.s. or 60 V ripple-free d.c., when the equipment is normally used in dry locations only and large-area contact of live parts with the human body is not to be expected;
   2) 6 V a.c. r.m.s. or 15 V ripple-free d.c. in all other cases;

b) the safety level is equivalent to that for SELV or PELV and supplied by one of the following sources:
   1) a safety isolating transformer;

      NOTE Safety isolating transformers are those that comply with IEC 61558-2-6.

   2) a source of current providing a degree of safety equivalent to that of a safety isolating transformer (e.g. motor generator);
   3) electrochemical (e. g. battery).

It shall be acknowledged that the precise value of this voltage limit depends on a great number of influencing factors (such as environmental conditions, contact area).

5.2.7 Limitation of steady-state touch current and energy

Limitation of steady-state touch current and energy is a provision whereby touch currents or energy is limited to non-dangerous values.

It shall prevent persons or livestock from being subjected to values of steady-state touch current and energy liable to be above the values given in Clause 5.

a) For touch current, the following values are proposed:
   – a steady-state current flowing between simultaneously accessible conductive parts not exceeding the threshold of perception, 0,5 mA a.c. or 2 mA d.c. under normal operating conditions;
   – values not exceeding the threshold of pain 3,5 mA a.c. or 10 mA d.c. may be specified under abnormal or fault conditions.

b) For stored energy available between simultaneously accessible conductive parts, the following values are proposed according to Figure 19 of IEC TS 60479-2:2007:
   – 0,5 mJ corresponding to the threshold of pain; and
   – 5 μJ corresponding to the threshold of perception.

Values for other frequencies, for other waveforms and for a.c. with superimposed d.c. are properly considered when measured with the appropriate IEC 60990 filtered touch current circuit.

NOTE Medical electrical equipment within the scope of the IEC 60601 series can necessitate other levels.

5.2.8 Potential grading

In the case of high-voltage installations and equipment, potential grading shall prevent persons or livestock from hazardous step and touch voltages under normal conditions by providing a potential grading earth electrode.

NOTE Potential grading is typically used for electrical railway systems and substations, where high earth currents occur.

5.2.9 Other provisions for basic protection

Any other provision for basic protection shall comply with the requirements of 4.1 for protection against electric shock.

5.3 Provisions for fault protection

5.3.1 General

Fault protection shall consist of one or more provision(s) independent of and additional to those for basic protection.

Subclauses 5.3.2 to 5.3.9 specify individual provisions for fault protection.

5.3.2 Supplementary insulation

Supplementary insulation is a provision whereby fault protection is provided by an insulation in addition to basic insulation.

Supplementary insulation shall be dimensioned to withstand the same stresses as specified for basic insulation.

5.3.3 Protective-equipotential-bonding

5.3.3.1 General

Protective-equipotential-bonding is a provision whereby items are bonded together to avoid hazardous touch voltages.

The protective-equipotential-bonding system shall consist of one or a suitable combination of two or more of the elements below:

– protective-equipotential-bonding in equipment, see Clause 7;
– earthed or unearthed protective-equipotential-bonding in the installation;
– protective conductor (PE);
– PEN, PEL or PEM conductor;
– protective screen;
– earthed point of the source or artificial neutral point;
– earth electrode (including earth electrodes for potential grading);
– earthing conductor.

The equipotential bonding system of a high-voltage installation or system shall be connected to earth because of the special risks, which may be present, e.g. the danger of high touch and

step voltage and of exposed-conductive-parts becoming live due to electrical discharge. The impedance to earth of the earthing arrangement shall be rated so that no hazardous touch voltage can occur. Exposed-conductive-parts, which can become live under fault conditions, shall be connected to the earthing arrangement.

5.3.3.2 Accessible conductive parts which could acquire a hazardous effective touch voltage in the event of a failure of basic protection, i.e. exposed-conductive-parts and any protective screen, shall be connected to the protective-equipotential-bonding system.

NOTE A conductive part of electrical equipment 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.

5.3.3.3 The protective-equipotential-bonding system shall be of sufficiently low impedance to avoid hazardous potential difference between conductive parts in case of an insulation failure. Where necessary the protective-equipotential-bonding system shall be used in association with a protective device operated by the fault current (see 5.3.6). The maximum difference in potential and its duration shall be based on IEC TR 60479-5.

This may necessitate consideration of the relative impedance values of the different elements of a protective-equipotential-bonding system.

The difference in potential need not be considered if the impedance of the circuit limits the steady-state touch current in the case of a single fault so that it cannot exceed 3,5 mA a.c., r.m.s. or 10 mA d.c. when measured in accordance with IEC 60990.

In some environments or situations, e.g. medical locations (see limit values in IEC 60601-1), highly conductive locations, wet areas and similar areas, the limit values need to be lower.

5.3.3.4 All parts of the protective-equipotential-bonding system shall be so dimensioned that thermal and dynamic stresses which are likely to occur do not impair the characteristics of the protective-equipotential-bonding system, e.g. as a consequence of a failure or bridging of basic insulation.

5.3.3.5 All parts of the protective-equipotential-bonding system shall be capable of withstanding all internal and external influences (including mechanical, thermal and corrosive) which may be expected.

5.3.3.6 Movable conductive connections, e.g. hinges and slides, shall not be considered to be parts of a protective-equipotential-bonding system unless compliance with the requirements of 5.3.3.3, 5.3.3.4 and 5.3.3.5 is maintained.

5.3.3.7 Where a component of an installation, system or equipment is intended to be removed, the protective-equipotential-bonding for any other part of the installation, system or equipment shall not be interrupted when removing the component unless the electrical supply to the other part is first disconnected.

5.3.3.8 With the exception described in 5.3.3.9, no element of the protective-equipotential-bonding system shall contain any device which might reasonably be expected to break the electrical continuity or introduce significant impedance.

This requirement may be dispensed with by technical committees for the verification of the continuity of protective conductors or for measuring of the current of the protective conductor.

5.3.3.9 Where elements of the protective-equipotential-bonding system can be interrupted by the same coupler or plug-and-socket-outlet device as the relevant supply conductors, the protective-equipotential-bonding system shall not be interrupted before the supply conductors. The protective-equipotential-bonding shall be re-established not later than when the supply conductors are reconnected. These requirements do not apply where interruption and reconnection are possible only with the equipment in de-energized condition.

In high-voltage installations, systems and equipment, the protective-equipotential-bonding system shall not be interrupted before the main contact has reached an isolating distance which can withstand the equipment rated impulse withstand voltage.

5.3.3.10 Conductors of the protective-equipotential-bonding system, whether insulated or bare, shall be readily distinguishable by shape, location, marking or colour, except those conductors which cannot be disconnected without destruction, e.g. in wire-wrap and similar wiring in electronic equipment and tracks on printed wiring boards. If identification by colour is used, it shall be in accordance with IEC 60445.

Conductors used only for functional earthing shall not have insulation coloured green-and-yellow.

5.3.4 Protective screening

Protective screening shall consist of a conductive screen interposed between hazardous-live-parts of an installation, system or equipment and the part being protected. The protective screen

– shall be connected to the protective-equipotential-bonding system of the installation, system or equipment and that interconnection shall comply with the requirements of 5.3.3, and
– shall itself comply with the requirements for elements of protective-equipotential-bonding system, see 5.3.3.3, 5.3.3.4 and 5.3.3.5.

5.3.5 Indication and disconnection in high-voltage installations and systems

A device shall be provided which indicates a fault. Depending on the method of neutral earthing, the fault current shall be disconnected either manually or automatically (see 5.3.6). The permissible value of the touch voltage depending on the fault duration shall be specified by technical committees based on IEC TS 60479-1.

5.3.6 Automatic disconnection of supply

5.3.6.1 General

For automatic disconnection of supply

– a protective-equipotential-bonding system shall be provided, and
– a protective device operated by the fault current shall disconnect the line conductor(s) supplying the equipment, system or installation, in the event of a fault of negligible impedance between a line conductor and an exposed-conductive-part or a protective conductor in the circuit or equipment.

For low-voltage applications, devices for protection against electric shock by automatic disconnection of supply shall be suitable for isolation according to 8.4. For high-voltage see 8.4.3.

5.3.6.2 The protective device shall interrupt the fault current within a time specified by technical committees based on the IEC 60479 series. For low-voltage installations, the time to be specified depends on the prospective touch voltage produced across the protective-equipotential-bonding.

For steady-state fault currents which, with regard to protection against electric shock, need not lead to disconnection, a conventional touch voltage limit U_L may be specified.

5.3.6.3 The protective device may be provided in any suitable upstream part of the installation, system or equipment, preferably at the origin of the circuit to be protected, and shall be selected taking into account the characteristics of the supply and the load, and of the impedance of the fault current loop.

5.3.7 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.

A component connected between the separated circuits shall withstand the electric stresses specified for the insulation which it bridges and its impedance shall limit the prospective current flow through the component to the steady-state touch current values indicated in 5.2.7.

5.3.8 Non-conducting environment

The environment shall have an impedance to earth of at least

– 50 kΩ if the nominal system voltage does not exceed 500 V a.c. or d.c.;

– 100 kΩ if the nominal system voltage is above 500 V a.c. or d.c. and does not exceed 1 000 V a.c. or 1 500 V d.c.

NOTE 1 Methods for measuring the resistance of insulating floors and walls are included in Annex A to IEC 60364-6: 2006.

NOTE 2 Impedance values for HV are not considered because this protective measure is not used.

5.3.9 Potential grading

Potential grading may be used by installation of additional earth electrodes to reduce the touch voltage and step voltage which appear in the case of a fault.

NOTE Earth electrodes are usually buried at a horizontal distance of 1 m from the equipment or any conductive part, at a depth of 0,5 m below ground level and are connected to the earthing arrangement.

5.3.10 Other provisions for fault protection

Any other provision for fault protection shall comply with the requirements of 4.1 for protection against electric shock.

5.4 Enhanced protective provisions

5.4.1 General

An enhanced protective provision shall provide both basic and fault protection.

Subclauses 5.4.2 to 5.4.6 specify such enhanced provisions.

Arrangements shall be made so that the protection provided by an enhanced protective provision is unlikely to become degraded and so that a single fault is unlikely to occur.

5.4.2 Reinforced insulation

Reinforced insulation shall be designed 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 3.10.1 and 3.10.2, respectively).

This requires design and test parameters more severe than those specified for basic insulation (see IEC 60664-1).

NOTE 1 As an example for low-voltage applications, dimensioning of reinforced insulation with regard to impulse voltage is, where the concept of overvoltage categories (see Clause 443 of IEC 60364-4-44:2007) applies, specified to comply with the requirements of the overvoltage category which is one category higher than that specified for basic insulation.

NOTE 2 Reinforced insulation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

5.4.3 Protective separation between circuits

Protective separation between a circuit and other circuits shall be achieved by means of

– basic insulation and supplementary insulation, each rated for the highest voltage present, i.e. double insulation, or
– reinforced insulation (see 5.4.2) rated for the highest voltage present, or
– protective screening (see 5.3.4) with the protective screen being separated from each adjacent circuit by basic insulation rated for the adjacent circuit voltage (see also 6.6), or
– 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 5.4.5.

5.4.4 Limited current source

A limited current source shall be so designed that it cannot supply touch currents in excess of the limit values indicated in 5.2.7.

The requirements of 5.2.7 apply also to any likely failure of a single component of the limited current source.

The limit values should be determined by the relevant technical committee.

5.4.5 Protective impedance device

A protective impedance device shall reliably limit the touch current to the values indicated in 5.2.7.

The protective impedance device shall withstand the electric stresses specified for the insulation which it bridges.

These requirements apply also to any likely failure of a single component of the protective impedance device.

5.4.6 Other provisions for enhanced protection

Any other enhanced protective provision for both basic protection and fault protection shall comply with the requirements of 4.1 for protection against electric shock.

5.5 Provisions for additional protection

5.5.1 Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30$ mA

In the case of low voltage, an RCD with $I_{\Delta n} \leq 30$ mA is applied as an additional protective provision where

a) basic protection is provided by one of the provisions of 5.2.2 (basic insulation) or 5.2.3 (protective barriers or enclosures), and/or

b) fault protection is provided by one of the provisions of 5.3.3 (protective-equipotential-bonding) and 5.3.6 (automatic disconnection of supply).

This protective provision is recognized as additional protection in the event of failure of the provision for basic protection and/or the provision for fault protection, or carelessness by users.

Devices for additional protection shall disconnect the live conductors by providing an isolating distance according to 8.4.

Residual current monitoring devices (RCMs) are not considered to be protective devices.

5.5.2 Additional protection by supplementary equipotential bonding

Additional protection by supplementary equipotential bonding is a provision whereby dangerous touch voltages are avoided by bonding of items.

Supplementary equipotential bonding is provided as an additional protective provision where

a) basic protection is provided by one of the provisions of 5.2.2 (basic insulation) or 5.2.3 (protective barriers or enclosures), and

b) fault protection is provided by protective earthing, protective equipotential bonding (5.3.3) and automatic disconnection in the event of a fault (5.3.6).

This protective provision will help avoid hazardous voltages between exposed-conductive-parts and extraneous-conductive-parts which can be touched simultaneously.

6 Protective measures

6.1 General

Clause 6 describes the structure of typical protective measures, indicating in some cases which protective provision(s) are for basic protection, for fault protection and for additional protection.

More than one of the following protective measures (see from 6.2 to 6.11) may be used within the same installation, system or equipment both under normal operating conditions and under single fault conditions.

The use of ELV other than that in accordance with 6.7 and 6.8 is not a protective measure

6.2 Protection by automatic disconnection of supply

Automatic disconnection of supply shall consist of a combination of the following protective provisions:

– basic protection is provided by basic insulation, or protective barriers or enclosures between hazardous-live-parts and exposed-conductive-parts; and

– fault protection is provided by automatic disconnection of supply.

Automatic disconnection of supply requires, according to 5.3.6, a protective-equipotential-bonding system as specified in 5.3.3. The relevant maximum disconnection times can be derived from IEC 60364-4-41.

6.3 Protection by double or reinforced insulation

Protective measure in which

– basic protection is provided by basic insulation of hazardous-live-parts and fault protection is provided by supplementary insulation,

or

– basic protection and fault protection are provided by reinforced insulation between hazardous-live-parts and accessible parts (accessible conductive parts and accessible surfaces of insulating material).

6.4 Protection by protective equipotential bonding

Protective measure in which

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts, and

– fault protection is provided by a protective equipotential bonding system preventing hazardous voltages between simultaneously accessible exposed and extraneous-conductive-parts.

6.5 Protection by electrical separation

Electrical separation is achieved where the following conditions are met:

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts of the separated circuit; and

– fault protection is provided

  - by simple separation of the separated circuit from other circuits and earth, and
  - by a protective-equipotential-bonding interconnecting exposed-conductive-parts of the separated circuit where more than one item of equipment is connected to the separated circuit. This protective-equipotential-bonding system shall not be earthed.

Intentional connection of exposed-conductive-parts to a protective earthing conductor or to an earthing conductor is not permitted.

NOTE Electrical separation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

6.6 Protection by non-conducting environment (low-voltage)

Protective measure in which

– basic protection is provided by basic insulation between hazardous-live-parts and exposed-conductive-parts, and

– fault protection is provided by the non-conducting environment.

6.7 Protection by SELV system

Protective measure in which protection is provided by

– limitation of voltage in a circuit to ELV limits as defined in Table 1(the SELV system), and
– protective separation of the SELV system from all circuits other than SELV and PELV, and
– simple separation of the SELV system from other SELV systems, from PELV systems and from earth.

Intentional connection of exposed-conductive-parts to a protective conductor or to an earthing conductor is not permitted.

In special locations where SELV is required and where protective screening according to 5.3.4 is applied, the protective screen shall be separated from each adjacent circuit by basic insulation intended for the highest voltage present.

6.8 Protection by PELV system

Protective measure in which protection is provided by:

– limitation of voltage in a circuit to ELV limits as defined in Table 1 and the circuit may be earthed and/or the exposed-conductive-parts of which may be earthed (the PELV system); and
– protective separation of the PELV system from all circuits other than SELV and PELV.

If the PELV circuit is earthed and if protective screening according to 5.3.4 is used, it is not necessary to provide basic insulation between the protective screen and the PELV system.

NOTE Where live parts of the PELV system are accessible simultaneously with conductive parts which, in case of a fault, could assume the potential of the primary circuit, protection against electric shock depends on protective-equipotential-bonding between all such conductive parts.

6.9 Protection by limitation of steady-state touch current and charge

Protective measure in which protection is provided by

– supply of a circuit:
  - from a limited current source, or
  - through a protective impedance device,

and

– protective separation of the circuit from hazardous-live-parts.

6.10 Additional protection

6.10.1 Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30$ mA

An RCD with $I_{\Delta n} \leq 30$ mA is used in addition to

– basic protection by basic insulation according to 5.2.2 or 5.2.3; and/or
– fault protection by one of the provisions of 5.3.3, 5.3.6 or 5.3.10.

The RCD for additional protection shall be suitable for isolation.

6.10.2 Additional protection by supplementary protective equipotential bonding

Supplementary protective-equipotential-bonding is used in addition to

– basic protection by basic insulation between hazardous-live-parts and exposed-conductive-parts, and

– fault protection by one of the provisions of 5.3.2, 5.3.3 or 5.3.10

by applying protective-equipotential-bonding to avoid hazardous voltages between exposed-conductive-parts and extraneous-conductive-parts which can be touched simultaneously.

6.11 Protection by other measures

Any other protective measure shall comply with the requirements of 4.1 for protection against electric shock and provide basic protection and fault protection.

7 Co-ordination between electrical equipment and protective provisions within an electrical installation

7.1 General

Protection is achieved by a combination of the constructional arrangements for the equipment and devices, together with the method of installation. Technical committees are recommended to use the protective measures described in Clause 6.

Current using equipment shall be classified in accordance with the classes of 7.2 to 7.5. The use of protective provisions in the several classes of equipment is described in 7.2 to 7.5 (see also Table 3).

If it is not appropriate to classify equipment and devices in this way, technical committees shall then specify the relevant methods of installation for their products.

For some equipment, the compliance with the classification can be achieved only after installation, e.g. where the installation prevents access to live parts. In this case, suitable instructions shall be provided by the manufacturer or responsible vendor.

Different protective measures applied to the same installation or part of an installation or within equipment shall have no influence on each other such that failure of one protective measure could impair the other protective measure or measures.

Table 3 – Application of equipment in a low-voltage installation

Class of equipment	Equipment marking or instructions	Symbol	Conditions for connection of the equipment to the installation
Class I	Marking of the protective bonding terminal with graphical symbol IEC 60417-5019:2006-08, or letters PE, or colour combination green-yellow		Connect this terminal to the protective-equipotential-bonding system of the installation
Class II	Marking with the graphical symbol IEC 60417-5172:2003-02 (double square)		No reliance on installation protective measures
Class III	Marking with the graphical symbol IEC 60417-5180:2003-02 (roman numeral III in a diamond)		Connect only to SELV or PELV systems

7.2 Class 0 equipment

Equipment with basic insulation as provision for basic protection and with no provisions for fault protection.

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts.

Class 0 shall only be used for equipment intended for connection by means of cord and plug to circuits operating at voltage not exceeding 150 V to earth.

However it is recommended that product committees withdraw class 0 from their product standards.

7.3 Class I equipment

7.3.1 General

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

7.3.2 Insulation

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts. This also applies to conductive parts which are separated by basic insulation but which are connected to hazardous-live-parts through components which are not designed for the same stresses as specified for basic insulation.

7.3.3 Connection to the protective conductor

Exposed-conductive-parts of the equipment shall be connected to the protective conductor terminal.

NOTE Exposed-conductive-parts include those parts which are covered only by paints, varnishes, lacquers and similar products.

Conductive parts which can be touched are not exposed-conductive-parts if they are separated from hazardous-live-parts by protective separation.

7.3.4 Accessible surfaces of parts of insulating material

If the equipment is not completely covered with conductive parts, the following applies to accessible parts of insulating material:

Accessible surfaces of parts of insulating material which

– are designed to be grasped, or
– are likely to come into contact with conductive surfaces which could distribute hazardous potential, or
– can come into significant contact (area more than 50 mm × 50 mm) with a part of the human body, or
– are to be used in areas where the pollution is highly conductive,

shall be separated from hazardous-live-parts by

– double or reinforced insulation, or
– basic insulation and protective screening, or
– a combination of these provisions.

All other accessible surfaces of parts of insulating material shall be separated from hazardous-live-parts by at least basic insulation. For equipment intended to be part of the fixed installation, the basic insulation shall be provided either by the manufacturer or during installation as specified by the manufacturer or responsible vendor in his instructions.

These requirements are deemed to be complied with if the accessible parts of insulating material provide the required insulation.

Technical committees may impose more stringent requirements than basic insulation for certain accessible parts of insulating material (e.g. which need to be touched frequently, such as operating means), taking into account the area of the contact surface with the human body.

7.3.5 Connection of a protective conductor

7.3.5.1 The means of connection, except for plug-and-socket connections, shall be clearly identified either with the graphical symbol IEC 60417-5019:2006-08, or with the letters PE, or by the bi-colour combination of green and yellow according to IEC 60445. The indication shall not be placed on or fixed by screws, washers or other parts which might be removed when conductors are being connected.

7.3.5.2 For flexible cable connected equipment, including fixed and plug-and-socket types, provisions shall be made such that the protective conductor in the cord shall, in case of failure of the strain-relief mechanism, be the last conductor to be interrupted.

7.4 Class II equipment

7.4.1 General

Class II equipment comprises equipment with

– 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.

7.4.2 Insulation

7.4.2.1 The accessible conductive parts and the accessible surfaces of parts of insulating material shall either be

– separated from hazardous live-parts by double or reinforced insulation, or

– designed with constructional arrangements providing equivalent protection, e.g. a protective impedance device.

For equipment intended to be part of the fixed installation, this requirement shall be fulfilled when the equipment is properly installed. This means that the insulation (basic, supplementary or reinforced) and the protective impedance, if relevant, shall be provided either by the manufacturer or during installation as specified by the manufacturer or responsible vendor in his instructions.

Arrangements providing equivalent fault protection may be defined by technical committees along with requirements appropriate to the nature of the equipment and its application.

7.4.2.2 All conductive parts which are separated from hazardous-live-parts by basic insulation only or by constructional arrangements providing equivalent protection shall be separated from the accessible surface by supplementary insulation or by constructional arrangements providing equivalent protection.

All conductive parts which are not separated from hazardous-live-parts by at least basic insulation shall be treated as if they were hazardous-live-parts, i.e. they shall be separated from the accessible surface in accordance with 7.4.2.1.

7.4.2.3 The enclosure shall not contain any screws or other fixing means of insulating material where these screws or other fixing means need to be removed or are likely to be removed during installation and maintenance and where the replacement of which by metallic screws or other fixing means could impair the insulation required.

7.4.2.4 The insulation of class II equipment shall comply with 5.1.6 of IEC 60664-1:2007.

7.4.3 Protective bonding

7.4.3.1 Class II equipment shall not have a provision for connection to a protective conductor except for applications according to 7.4.3.2.

7.4.3.2 Where a class II equipment is provided with means for maintaining the continuity of a protective conductor, but in all other respects is constructed as class II equipment, such means shall be insulated in accordance with 7.4.2.1.

Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which run through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be marked as PE terminals.

7.4.3.3 Class II equipment may be provided with means for connection to earth for functional (as distinct from protective) purposes only where such a need is recognized in the relevant IEC standard. Such means shall be insulated from live parts by double or reinforced insulation. The means for functional earthing shall have a distinctive marking from the means for protective earthing and shall not be connected by a conductor identified as PE in accordance with IEC 60445.

NOTE A functional earthing can be used for example for EMC purposes.

7.4.4 Marking

Class II equipment, including equipment complying with 7.4.3.1, shall be marked with the graphical symbol of IEC 60417-5172:2003-02, placed adjacent to the supply information, e.g. on the rating plate, in such a way that it is obvious that the symbol is part of the technical information and can in no way be confused with the manufacturer's name or other identification marks.

Where a class II equipment has a functional earthing terminal, this terminal shall be identified with the graphical symbol IEC 60417-5018: 2011-07.

7.5 Class III equipment

7.5.1 General

Equipment relying on limitation of voltage to ELV values as provision for basic protection and with no provision for fault protection.

7.5.2 Voltages

7.5.2.1 Equipment shall be designed for a maximum nominal voltage not exceeding 50 V a.c. or 120 V d.c. (ripple-free).

NOTE 1 Ripple-free is conventionally defined as an r.m.s. ripple voltage of not more than 10 % of the d.c. component. Maximum values for non-sinusoidal a.c. voltage are under consideration.

NOTE 2 According to Clause 414 of IEC 60364-4-41:2005, class III equipment is accepted only for connection to SELV and PELV systems.

Technical committees should determine the maximum permitted rated voltage of their products in accordance with IEC TS 61201 and the specified conditions of use of these products.

7.5.2.2 Internal circuits may operate at any nominal voltage which does not exceed the limits specified in 7.5.2.1.

7.5.2.3 In case of a single fault within the equipment, no steady-state touch voltage which may appear or be generated shall exceed the limits specified in 7.5.2.1.

7.5.3 Protective bonding

Class III equipment shall not be provided with a means of connection for a protective conductor. The equipment may however be provided with means for connection to earth for functional (as distinct from protective) purposes where such a need is recognized in the relevant IEC standard. In any case, provision for the connection of live parts to earth shall not be made in the equipment.

The means for functional earthing shall have a distinctive from that used for a means for protective earthing and shall not be connected by a conductor identified as PE in accordance with IEC 60445.

7.5.4 Marking

The equipment shall be marked with the graphical symbol of IEC 60417-5180:2003-02. This requirement does not apply where the means of connection to the supply is so shaped that it can only mate exclusively with a particularly designed SELV or PELV supply arrangement.

7.6 Touch currents, protective conductor currents

7.6.1 General

Subclause 7.6 is applicable only to low-voltage installations, systems and equipment.

The requirements of 7.6 take into account equipment intended to be supplied by plug and socket-outlet systems, or by a permanent connection, or the case of stationary equipment.

NOTE The effects of leakage current are currently not considered in this standard.

7.6.2 Touch currents

Measures shall be taken so that when accessible parts are touched under normal condition, the touch current does not exceed the threshold of perception as indicated in IEC TS 60479-1. The touch currents shall be measured according to IEC 60990. Where additional touch current is allowed under fault conditions, product committees shall specifically identify in their standards the conditions and the additional current allowed.

NOTE 1 See Figure 20 of IEC TS 60479-1:2005 for a.c. 50Hz and/or 60Hz and Figure 22 for d.c.

NOTE 2 Values for frequencies up to 10 kHz can be obtained from Figures 1 and 4 of IEC 60479-2:2007. For frequencies above 10 kHz, see 4.4 of IEC 60479-2:2007.

7.6.3 Protective conductor currents

7.6.3.1 General

Measures shall be taken in the installation and in equipment to prevent excessive protective conductor currents impairing safety or normal use of the electrical installation.

Technical committees shall determine that the correct operation of protective devices, e.g. RCDs and CBs, is not affected by the protective conductor current generated by products or systems under their scope.

Manufacturers shall make available information on the value and characteristics of the expected protective conductor current under normal operating conditions. For frequencies

other than 50 Hz and/or 60 Hz product committees are encouraged to use the lowest practicable values of protective conductor current limits.

7.6.3.2 Requirements for the prevention of excessive protective conductor currents of current-using equipment

Electrical equipment which causes, under normal conditions, a current to flow in the protective conductor of its supply, shall be compatible with protective provisions.

7.6.3.3 Limits of a.c. components of protective conductor currents of current-using equipment

The limit values for protective conductor currents under normal operating conditions as given by Table 4 are applicable to low-voltage current-using equipment supplied at rated frequencies up to 1 kHz.

Table 4 – Maximum protective conductor current for frequencies up to 1 kHz

Rated current of current-using equipment a.c.	Maximum protective conductor current for frequencies up to 1 kHz
$0 < I \leq 2$ A	1 mA
2 A $< I \leq 20$ A	0,5 mA/A
$I > 20$ A	10 mA

For current-using equipment for permanent connection intended to be connected to a reinforced protective conductor according to 7.6.3.5, product committees should state the maximum values for the protective conductor current, which in no case shall exceed 5 % of the rated input current per phase.

Measurements shall be carried out on equipment as delivered.

7.6.3.4 Limits of d.c. components of protective conductor current

In normal use, a.c. current using equipment shall not generate current with a d.c. component in the protective conductor that exceeds the values in Table 5. This will prevent affecting the proper functioning of protective device(s) or other equipment in the installation.

Table 5 – Maximum protective conductor current for DC

Rated current of current-using equipment a.c.	Maximum protective conductor current d.c.
$I \leq 2$ A	5 mA
2 A $< I \leq 20$ A	2,5 mA/A
$I > 20$ A	50 mA

Pluggable electrical equipment with a rated input ≤ 4 kVA shall be designed to have protective conductor current with a smooth superimposed d.c. current component limited to ≤ 6 mA.

For pluggable electrical equipment with a rated input > 4 kVA and permanently connected electrical equipment independent of the rated input shall contain in the operating manual advice about the protective measure.

In case of d.c. protective conductor currents > 6 mA, suitable protective devices shall be selected, e.g. RCD type B.

7.6.3.5 Provisions in equipment in case of connection to reinforced protective conductor circuits for protective conductor currents exceeding 10 mA

The following shall be provided in the current-using equipment:

– a connecting terminal designed for the connection of a protective conductor, having a cross-sectional area of at least of 10 mm^2 Cu or 16 mm^2 Al; or

– a second terminal designed for the connection of a protective conductor of the same cross-section as that of the normal protective conductor so as to connect a second protective conductor to the current-using equipment.

NOTE For requirements for reinforced protective conductors, see 543.7 of IEC 60364-5-54:2011.

7.6.3.6 Information

For equipment intended for permanent connection with reinforced protective conductor, the value of the protective conductor current shall be provided by the manufacturer in his documentation and indication shall be given in the instructions for installation that the equipment shall be installed as described in 7.6.4.2.

7.6.4 Other requirements

7.6.4.1 Signalling systems

The use of a protective conductor of an electrical installation for signalling is not allowed.

7.6.4.2 Reinforced protective conductor circuits in installations for protective conductor currents exceeding 10 mA

For current-using equipment intended for permanent connection and having a protective conductor current higher than 10 mA, provision shall be made for a secure and reliable connection with earth such as described in IEC 60364-5-54.

7.6.5 Other effects

Muscular contractions and thermal effects caused by current passing through the human body or livestock and effects of discharge of electrostatic charges may also but not generally lead to hazardous situations.

Technical committees shall take into consideration

– that persons or livestock could become energized by currents of values as described in 4.5.1 resulting from contact with metal parts. It might be necessary to specify additional precautions to prevent the users from experiencing involuntary muscular contractions.

– that persons or livestock could be subjected to values of touch current and charge liable to be hazardous or perceptible (see 4.6.3).

– that due to the effect of currents as described in 4.6.4 flowing in the human body or livestock for more than a few seconds, deep seated burns, and other internal injuries (e.g. kidney failure), could occur. Surface burns may also arise.

7.7 Safety and boundary clearances and hazard marking for high-voltage installations

The design of the installation shall be such as to restrict access to danger zones. For skilled and instructed persons the need for operational and maintenance access shall be taken into account. Where safety distances cannot be achieved, permanent protective facilities shall be installed. Values shall be specified by technical committee(s) for

– barrier clearances,

– obstacle clearances,

– external fences and access doors,

– minimum height and distance from access areas,

– clearances to buildings.

Hazard markings shall be prominently displayed on all access doors, fences, protective barriers and overhead line poles and towers, etc.

7.8 Functional earthing

Equipment may be provided with means for connection to earth for functional (as distinct from protective) purposes only where such a need is recognized in the relevant IEC standard (e.g. for EMC purposes). Such means shall be

– insulated from live parts, and

– insulated from exposed conductive parts except where exposed conductive parts are connected to a protective bonding terminal, e.g. in case of PELV equipment.

The means for functional earthing shall have a marking or other identification in accordance with IEC 60445.

8 Special operating and servicing conditions

8.1 General

Detailed requirements for operation of electrical installations, e.g.

– live working;

– de-energized working;

– working close to live parts

are subjects for consideration by appropriate technical committees.

8.2 Devices to be operated manually and components intended to be replaced manually

8.2.1 General

NOTE 1 Examples include:

– devices which need to be reset (e.g. circuit-breakers, overcurrent/overvoltage/undervoltage devices);

– replaceable components (e.g. lamps, fuselinks)

for (re)establishing the function of the installation, system or equipment. Subclause 8.2.2 also applies to access for user maintenance.

NOTE 2 For the purpose of this standard, "manually" means "by hand, with or without a tool".

8.2.2 Devices to be operated or components intended to be replaced by ordinary persons in low-voltage installations, systems and equipment

8.2.2.1 General

Protection against any contact with hazardous-live-parts shall be maintained when operating devices or when replacing components.

NOTE It is recognized that certain lamp-holders and fuse-holders, complying with existing standards, do not fulfil this requirement when the components are being replaced.

8.2.2.2 Where installations, systems or equipment incorporate devices which require manual operation, or components which require manual replacement, these devices and components shall be located where no hazardous-live-parts are accessible.

8.2.2.3 Where compliance with 8.2.2.2 is not practicable, protection shall be provided by means which ensure isolation from the electrical supply before access is gained.

8.2.3 Devices to be operated or components intended to be replaced by skilled or instructed persons

8.2.3.1 General

Protection against unintentional access to hazardous-live-parts or against unintentionally entering the danger zone shall be provided according to 8.2.3.2 and 8.2.3.3 where either

– there are no protective barriers or enclosures, or

– protective barriers or enclosures are to be removed by skilled or instructed persons to gain access to devices requiring manual operation or to components requiring replacement.

Technical committees may restrict the application of this subclause or impose additional requirements and specify the kind of manual operation for which this method of protection is permitted.

8.2.3.2 Location of devices and components

The equipment shall be so designed and installed that the devices and components are accessible and visible to a person who is in a position where he or she may readily and safely operate the device or replace the component.

Such positions and relevant information to be supplied by the manufacturer should be specified by technical committees, as appropriate.

If the mounting position of equipment may adversely affect the visibility or access to devices or components in such a way as to cause a hazard, then the required mounting position shall be indicated and observed.

In case of the presence of a.c. and d.c. circuits in the same equipment and/or installation, the a.c. and d.c. conductors shall be provided with distinct identification

8.2.3.3 Accessibility and operation

The access path to a device and the space needed for its operation shall be such that protection against unintentional contact with hazardous-live-parts or against unintentionally entering the danger zone is provided by an appropriate distance. The distance shall be specified by the technical committee.

Alternatively, where the access path or space has less than the appropriate distance from hazardous-live-parts, obstacles shall be provided. These obstacles shall provide protection against unintentional contact. The degree of protection shall be not less than IPXXB (also complied with by IP2X) of IEC 60529 from the direction of approach to the device or component, and not less than IPXXA (also complied with by IP1X) of IEC 60529 from other appropriate directions.

8.3 Electrical values after isolation

Where protection relies on isolation of hazardous-live-parts from the supply (e.g. when opening enclosures or removing protective barriers), capacitances shall be automatically discharged so that 5 s after isolation, the limit values of voltage specified in Annex A of IEC TS 61201:2007 will not be exceeded. If this would interfere with proper functioning of the

equipment, a readily visible warning notice shall be provided, indicating the time of discharge to the limit values.

For particular conditions (e.g. withdrawal of a plug), technical committees may have to specify a shorter time.

After isolating, particularly with high voltages, the following effects should be considered:

– capacitors can have high residual charges;
– inductances, e.g. transformer windings, can have a high trapped charge over a relatively long period of time.

8.4 Devices for isolation

8.4.1 General

Devices suitable for isolation shall effectively isolate the circuit concerned from all live conductors of the supply.

NOTE 1 With regard to low voltage, see also 8.4.2.

The position of the contacts or other means of isolation shall, in the isolated position, be either externally visible or clearly and reliably indicated.

NOTE 2 The indication can be achieved by suitable marking to indicate the isolated and closed positions respectively.

Devices suitable for isolation shall be designed and/or erected to prevent unintentional or unauthorized operation.

NOTE 3 Such operation might be caused for example by mechanical shocks and vibrations.

8.4.2 Devices for isolation for low voltage

Devices suitable for isolation shall effectively isolate the circuit concerned from all live conductors of the supply. However, in TN-S or TN-C-S systems where the supply system conditions are such that the neutral or mid-point conductor can be regarded as being reliably at earth potential, the neutral conductor need not be isolated.

Devices for isolation shall comply with the following two conditions:

a) When in the new, clean and dry condition, with the contacts in the position for isolation, the device shall withstand between the line and load terminals, the impulse withstand voltage given in Table 6.

Table 6 – Minimum impulse withstand voltage of devices for isolation related to the nominal voltage

Nominal voltage of the supply system [a] V		Minimum impulse withstand voltage [b] kV	
Three-phase systems	**Single-phase systems with middle point**	**Overvoltage category III**	**Overvoltage category IV**
	120 – 240	3	5
230/400, 277/480		5	8
400/690		8	10
1 000		10	15
NOTE 1 For an explanation of the overvoltage categories, see 4.3.3.2 of IEC 60664-1:2007.			
NOTE 2 The impulse withstand voltages are referred to an altitude of 2 000 m.			
NOTE 3 The values of 100/200V, 50Hz or 60Hz are also used in some countries.			
[a] According to IEC 60038.			
[b] Equipment of overvoltage category II and I are not applicable for isolation.			

b) The leakage current across open poles shall under no circumstances exceed
   - 0,5 mA per pole in the new, clean and dry condition, and
   - 6 mA per pole, at the end of the conventional service life of the device,

   when tested across the terminals of each pole with a test voltage value equal to 110 % of the voltage between line to neutral corresponding to the rated voltage of equipment, when the starpoint or midpoint of the supply is connected to earth. In all other cases the test voltage value shall be equal to 110 % of the line-to-line voltage of the supply system.

   In the case of d.c. testing, the value of the d.c. voltage shall be the same as the r.m.s. value of the a.c. test voltage.

Tests to verify this requirement may be specified by the relevant technical committee.

8.4.3 Devices for isolation for high voltage

8.4.3.1 General

Every isolating device shall be suitable for the assigned purpose.

All general requirements, e.g. earthing arrangements and if necessary the special requirements of the location, e.g. altitude, shall be stated and taken into consideration.

All isolated parts of the main circuit to which access is required or provided shall be capable of being earthed prior to becoming accessible. This requirement does not necessarily apply to removable parts that become accessible after being separated from the installation.

The corresponding specifications for the assigned equipment shall be designed taking into account the network configuration, the local particular conditions and the experiences of operation and maintenance.

It shall be taken into consideration that the expected electrical stresses are not only those found in normal operation, but also additional stresses, for example in case of a short-circuit fault.

Lightning and switching overvoltages shall be also taken into consideration.

Mechanical, climatic and other special stresses which belong to external influences at the site of installation shall be considered during the design process of the equipment.

NOTE Besides these stresses, it is important to pay attention to IEC 60071-1, insulation coordination, by the selection of a suitable switching device.

To avoid unintentional operation, a facility for locking of the isolating device for safety reasons shall be available in the "on" and "off" position.

For the construction or installation of devices for isolation it should be taken into consideration that electric arcs or hot ionizing gases may be generated when switching off. Therefore equipment should be designed or installed in such a way that ionized gas released during switching does not result in damage to the equipment or in danger to operating personnel. This is valid also if there is a secondary flashover by ionization to parts which are not live parts.

8.4.3.2 Characteristics of devices for isolation

Devices for isolation shall comply with the performances defined for longitudinal insulation. That is satisfied when the isolating distance has the dielectric performances specified in IEC 62271-102 for that purpose.

For safety reasons, devices for isolation shall be designed so that any earth leakage current which may flow from one contact to the terminal on the other side of the isolator is limited to an acceptable level. This safety requirement is fulfilled if this leakage current is reliably dissipated to earth.

Annex A
(informative)

Survey of protective measures as implemented by protective provisions

NOTE Not all of the protective provisions are applicable to both low-voltage and high-voltage.

Figure A.1 shows the relationship between protective measures and their respective provisions for basic protection and fault protection.

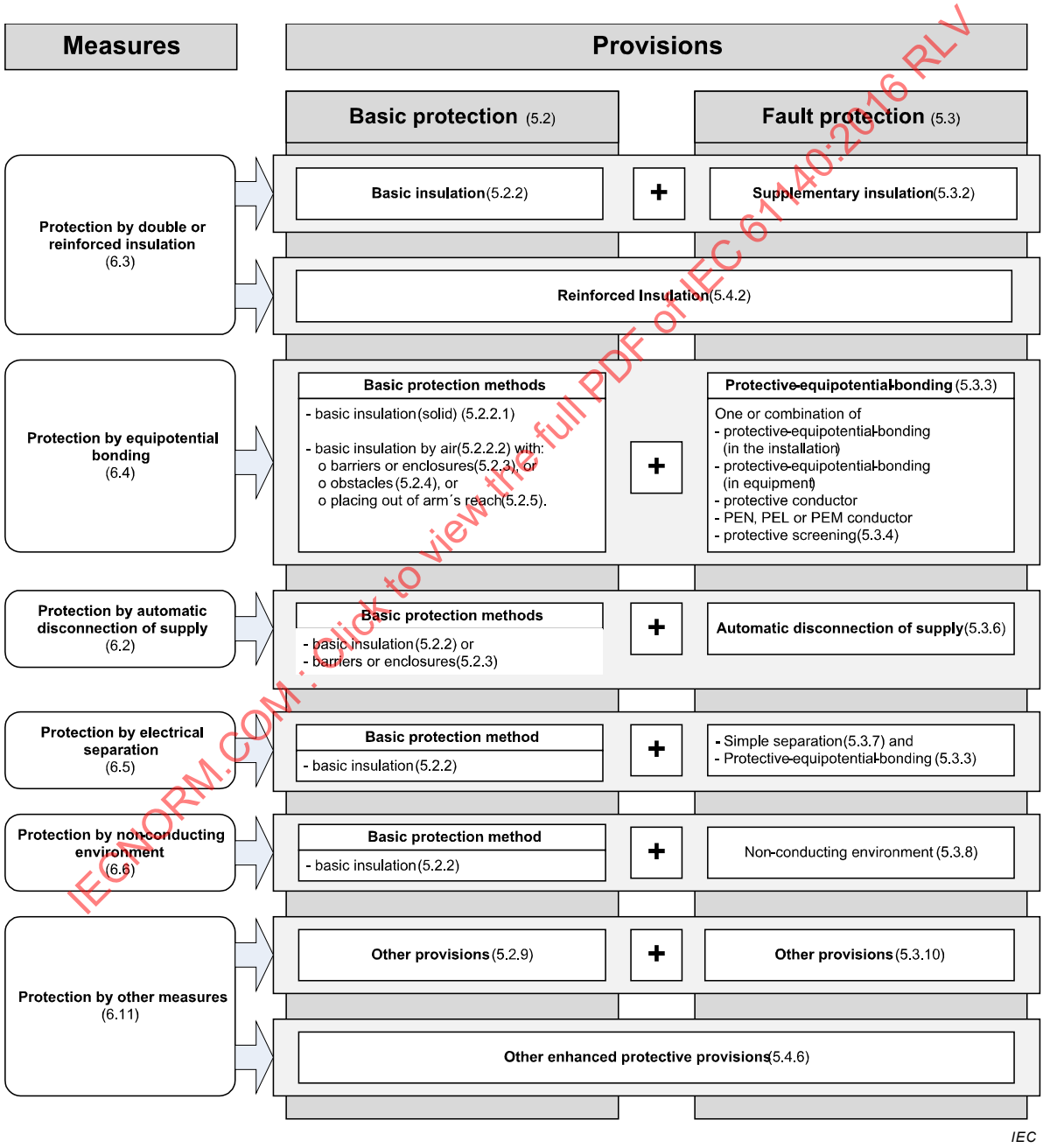

Figure A.1 – Protective measures with basic and fault protection

Figure A.2 shows the relationship between protective measures with limited values of electrical quantities and their respective provisions

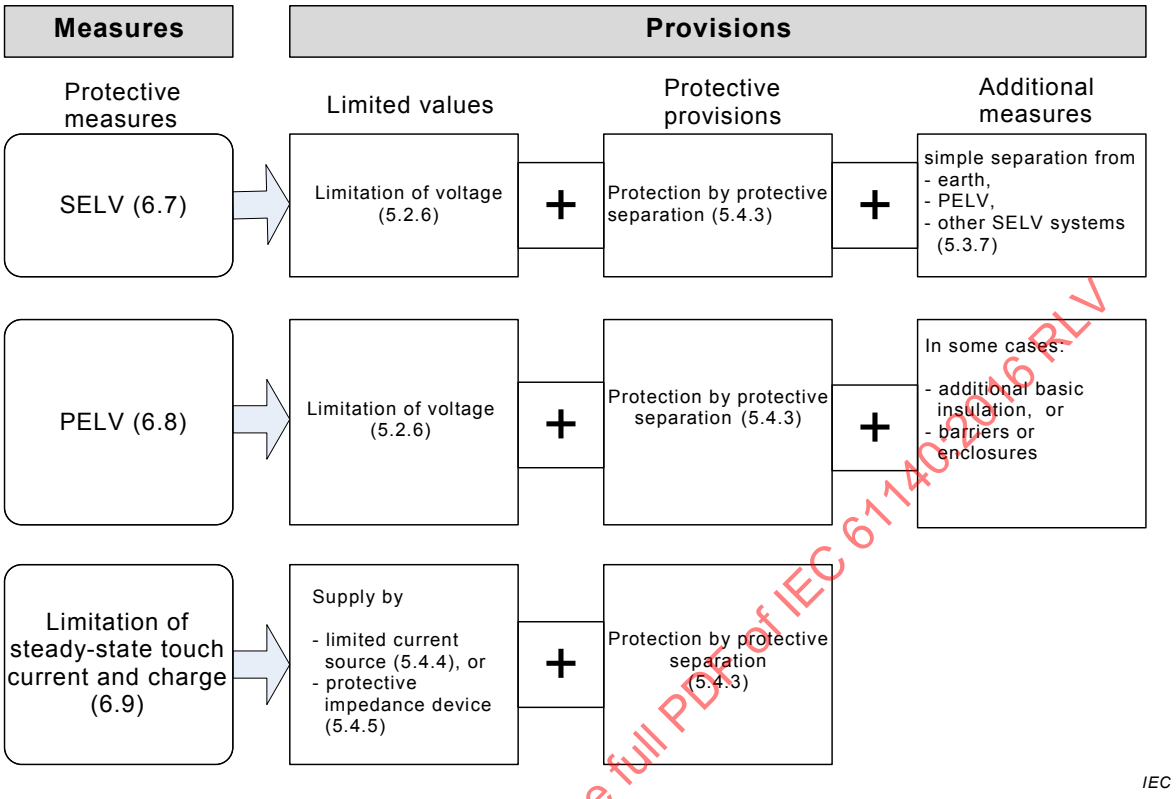

Figure A.2 – Protective measures with limited values of electrical quantities

Figure A.3 shows the relationship between protective measures for additional protection and their respective provisions

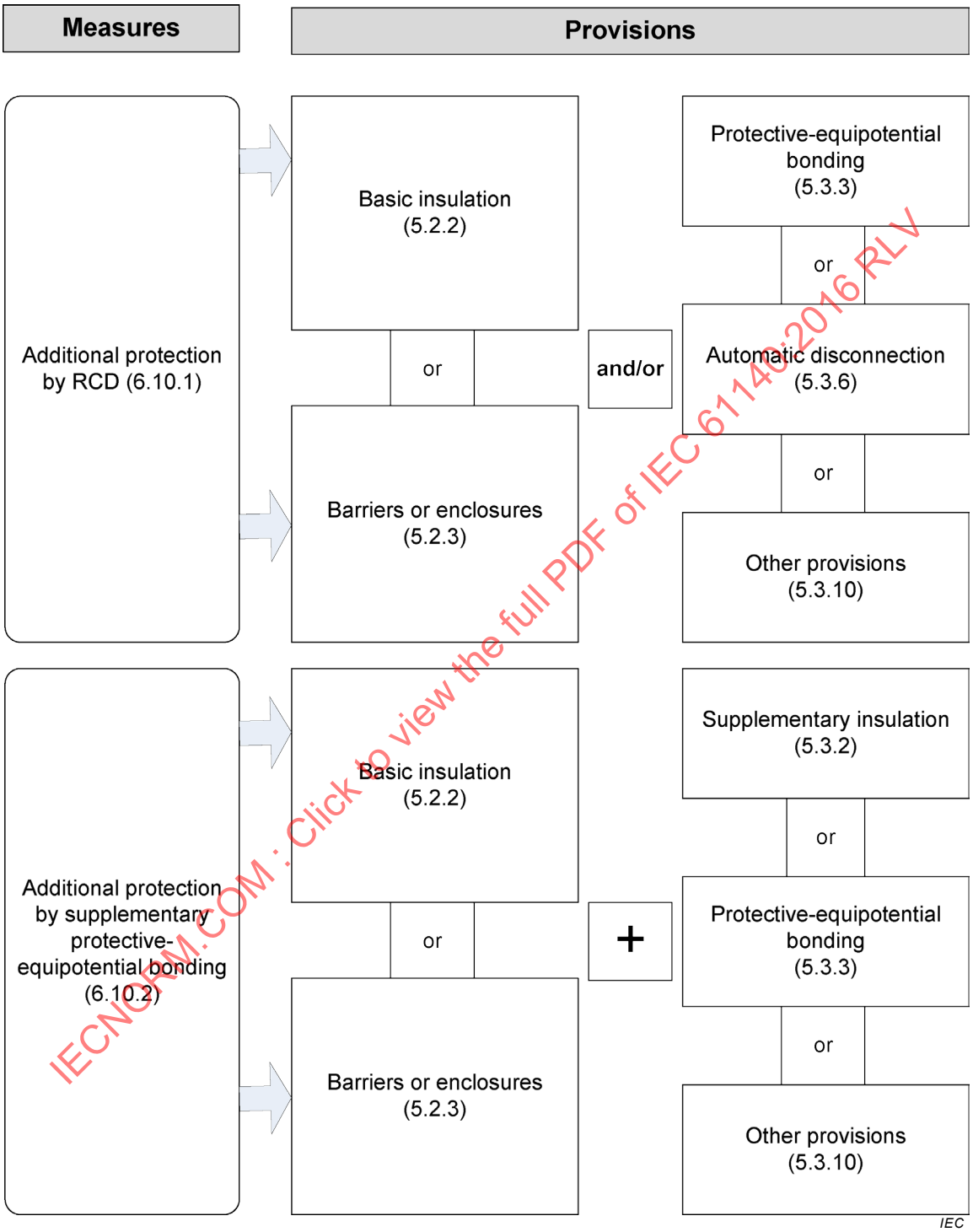

Figure A.3 – Protective measure: additional protection (in addition to basic and/or fault protection)

Annex B
(informative)

Index of terms

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ground electrode (US)	3.17.4
ground, (local) (US)	3.17.3
ground, reference (US)	3.17.2
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grounding conductor (US)	3.17.5
grounding, functional (US)	3.17.8
grounding, protective (US)	3.17.7
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Annex C
(informative)

List of notes concerning certain countries

Country	Clause N°	Nature (permanent or less permanent according to IEC Directives)	Rationale (detailed justification for the requested country note)	Wording
PT	3.1.1			In Portugal for low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact.
PT	3.1.2			In Portugal for low-voltage installations, systems and equipment fault protection generally corresponds to protection against indirect contact.
AT	6.5	permanent	long practical experiences and physical facts	– In Austria, in case of using a transformer as source for protection by electrical separation a safety isolating transformer complying with IEC 61558-2-6 is required. – In Austria, the protective-equipotential-bonding system needs not to be earthed. Under certain conditions, an intentional earthing of the interconnecting conductor or the exposed-conductive-parts of the current-using equipment is allowed.
IT	7.2			In Italy class 0 shall not be used for the design and manufacture of equipments.
US	7.3.5.1			In the USA, solid colour green is also used to indicate the terminal for connection to the protective conductor.

Bibliography

IEC 60050-195:1998, *International Electrotechnical Vocabulary – Part 195: Earthing and protection against electric shock*
IEC 60050-195:1998/AMD1:2001

IEC 60050-351, *International Electrotechnical Vocabulary – Part 351: Control technology*

IEC 60050-826:2004, *International Electrotechnical Vocabulary – Part 826: Electrical installations*

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

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-6:2006, *Low-voltage electrical installations – Part 6: Verification*

IEC 60479 (all parts), *Effects of current on human beings and livestock*

IEC TS 60479-2:2007, *Effects of current on human beings and livestock – Part 2: Special aspects*

IEC 60601-1, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

Additional non-cited references

IEC 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory*

IEC 61936-1, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC TS 61936-2, *Power installations exceeding 1 kV a.c. and 1,5 kV d.c. – Part 2: d.c.*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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PROTECTION CONTRE LES CHOCS ÉLECTRIQUES – ASPECTS COMMUNS AUX INSTALLATIONS ET AUX MATÉRIELS

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La Norme internationale IEC 61140 a été établie par le comité d'études 64 de l'IEC: Installations électriques et protection contre les chocs électriques.

Cette quatrième édition annule et remplace la troisième édition parue en 2001 et l'Amendement 1:2004. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) Introduction du contenu de l'IEC 60449
b) Meilleure distinction entre les dispositions et les mesures
c) Prise en compte des effets autres que la fibrillation ventriculaire
d) Introduction d'une protection complémentaire
e) TBT définie comme partie intégrante de BT

f) Dispositifs adaptés au sectionnement exigés pour la coupure automatique de l'alimentation (BT)

g) Les exigences relatives au courant circulant dans le conducteur de protection ont été déplacées dans le corps du texte de la norme

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
64/2076/FDIS	64/2091/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Elle a le statut d'une publication fondamentale de sécurité conformément au Guide IEC 104.

L'attention du lecteur est attirée sur le fait que l'Annexe C énumère tous les articles traitant des différences à caractère moins permanent inhérentes à certains pays, concernant le sujet de la présente norme.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

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- remplacée par une édition révisée, ou
- amendée.

PROTECTION CONTRE LES CHOCS ÉLECTRIQUES – ASPECTS COMMUNS AUX INSTALLATIONS ET AUX MATÉRIELS

1 Domaine d'application

La présente Norme internationale est une publication fondamentale de sécurité avant tout destinée à être utilisée par les comités d'études lors de l'élaboration de normes conformément aux principes établis dans le Guide IEC 104 et le Guide ISO/IEC 51.

Elle n'est pas destinée à être utilisée seule.

Conformément au Guide 104, il est demandé aux comités d'études, lors de l'élaboration, de l'amendement ou de la révision de leurs publications, d'utiliser toute publication fondamentale de sécurité applicable, telle que l'IEC 61140.

La présente Norme internationale est applicable à la protection des personnes et des animaux d'élevage contre les chocs électriques. Elle est destinée à donner des principes fondamentaux et des exigences communes aux installations, aux systèmes et aux matériels électriques, ou nécessaires à leur coordination sans limitation en ce qui concerne l'amplitude de tension ou de courant, ou le type de courant, et pour des fréquences jusqu'à 1 000 Hz.

Certains articles dans la présente norme se réfèrent à des systèmes, installations et matériels à basse tension et à haute tension. Pour les besoins de la présente norme, la basse tension correspond à toute tension assignée jusqu'à et y compris 1 000 V en courant alternatif ou 1 500 V en courant continu. La haute tension correspond à toute tension assignée supérieure à 1 000 V en courant alternatif ou 1 500 V en courant continu.

Il convient de noter que, pour une conception et une sélection efficaces des mesures de prévention, il est nécessaire de considérer le type de tension qui peut survenir et sa forme d'onde, c'est-à-dire la tension en courant alternatif ou en courant continu, sinusoïdale, transitoire, à commande de phase, en courant continu superposé, ainsi qu'un éventuel mélange de ces formes. Les installations ou matériels peuvent influencer la forme d'onde de la tension, par exemple, au moyen d'onduleurs ou de convertisseurs. Les courants circulant dans des conditions normales de fonctionnement et dans des conditions de défaut dépendent de la tension décrite.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60038, *Tensions normales de la CEI*

IEC 60068 (toutes les parties), *Essais d'environnement*

IEC 60071-1, *Coordination de l'isolement – Partie 1: Définitions, principes et règles*

IEC 60071-2, *Coordination de l'isolement – Partie 2: Guide d'application*

IEC 60364-5-54:2011, *Installations électriques basse-tension – Partie 5-54: Choix et mise en œuvre des matériels électriques – Installations de mise à la terre et conducteurs de protection*

IEC 60417, *Symboles graphiques utilisables sur le matériel* (disponible à l'adresse http://www.graphical-symbols.info/equipment)

IEC 60445, *Principes fondamentaux et de sécurité pour les interfaces homme-machines, le marquage et l'identification – Identification des bornes de matériels, des extrémités de conducteurs et des conducteurs*

IEC TS 60479-1:2005, *Effets du courant sur l'homme et les animaux domestiques – Partie 1: Aspects généraux*

IEC TR 60479-5, *Effets du courant sur l'homme et les animaux domestiques – Partie 5: Valeurs des seuils de tension de contact pour les effets physiologiques*

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60664 (toutes les parties), *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension*

IEC 60664-1:2007, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

IEC 60721 (toutes les parties), *Classification des conditions d'environnement*

IEC 60990, *Méthodes de mesure du courant de contact et du courant dans le conducteur de protection*

IEC TS 61201:2007, *Utilisation des tensions limites conventionnelles de contact – Guide d'application*

IEC 62271-102, *Appareillage à haute tension – Partie 102: Sectionneurs et sectionneurs de terre à courant alternatif*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications* (disponible en anglais seulement)

ISO/IEC Guide 51:2014, *Aspects liés à la sécurité – Principes directeurs pour les inclure dans les normes*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

NOTE Un index des définitions est donné à l'Annexe B.

3.1
choc électrique
effet physiologique résultant du passage d'un courant électrique à travers le corps humain ou celui d'un animal d'élevage

Note 1 à l'article: Les effets physiologiques incluent, par exemple, la perception, les contractions musculaires et la tétanie, les difficultés respiratoires, les troubles de la fonction du cœur, l'immobilisation, l'arrêt cardiaque, l'arrêt respiratoire, les brûlures ou autres atteintes cellulaires.

Note 2 à l'article: Les effets physiologiques résultant de la FEM ne sont pas considérés dans la présente norme.

[SOURCE: IEC 60050-195:1998, 195-01-04, modifiée – "à travers le corps humain ou celui d'un animal d'élevage" remplace "à travers le corps humain ou celui d'un animal"; ajout de 2 Notes à l'article]

3.1.1
protection principale
protection contre les chocs électriques en l'absence de défaut

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

3.1.2
protection en cas de défaut
protection contre les chocs électriques dans des conditions de premier défaut

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-02]

3.1.3
protection complémentaire
protection contre les chocs électriques en complément de la protection principale et/ou de la protection en cas de défaut

[SOURCE: IEC 60050-826:2004, 826-12-07, modifiée – "protection contre les chocs électriques" remplace "mesure de protection"]

3.1.4
condition de premier défaut
état dans lequel un moyen de protection contre les chocs électriques est défectueux ou un défaut est présent, ce qui peut entraîner un danger

Note 1 à l'article: Si une condition de premier défaut engendre une ou plusieurs autres conditions de défaut, toutes sont considérées comme une seule condition de premier défaut.

3.2
circuit électrique
ensemble de dispositifs ou de milieux dans lesquels peuvent circuler des courants électriques

Note 1 à l'article: Voir également l'IEC 60050-826:2004, 826-14-01 pour les installations électriques des bâtiments.

3.3
matériel électrique
matériel utilisé pour la production, la transformation, le transport, la distribution ou l'utilisation de l'énergie électrique, tel que machine, transformateur, appareillage, appareil de mesure, dispositif de protection, canalisation électrique, matériels d'utilisation

[SOURCE: IEC 60050-826:2004, 826-16-01]

3.4
partie active
partie conductrice destinée à être sous tension dans des conditions normales, y compris le conducteur de neutre ou le conducteur de point milieu, mais par convention, excepté le conducteur PEN, le conducteur PEM ou le conducteur PEL

Note 1 à l'article: La notion n'implique pas nécessairement un risque de choc électrique.

[SOURCE: IEC 60050-195:1998, 195-02-19, modifiée – "…conditions normales, y compris le conducteur de neutre ou le conducteur de point milieu" remplace "service normal, y compris le conducteur de neutre.."]

3.5
partie active dangereuse
partie active qui peut provoquer, dans certaines conditions, un choc électrique nuisible

Note 1 à l'article: En haute tension, une tension dangereuse peut être présente à la surface d'une isolation solide. Dans ce cas, la surface est considérée comme une partie active dangereuse.

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

3.6
partie conductrice accessible
masse (dans une installation)
partie conductrice d'un matériel, susceptible d'être touchée, et qui n'est pas normalement sous tension mais peut le devenir lorsque l'isolation principale est défaillante

Note 1 à l'article: Une partie conductrice d'un matériel électrique qui ne peut être mise sous tension que par l'intermédiaire d'une partie conductrice accessible qui est devenue sous tension, n'est pas considérée comme une partie conductrice accessible.

[SOURCE: IEC 60050-195:1998, 195-06-10]

3.7
élément conducteur étranger
partie conductrice ne faisant pas partie de l'installation électrique et susceptible d'introduire un potentiel électrique, généralement celui d'une terre locale

[SOURCE: IEC 60050-195:1998, 195-06-11]

3.8
tension de contact

3.8.1
tension de contact (effective)
tension de toucher effective
tension entre des parties conductrices touchées simultanément par une personne ou un animal d'élevage

Note 1 à l'article: La valeur de la tension de contact effective peut être sensiblement influencée par l'impédance de la personne ou de l'animal d'élevage en contact électrique avec ces parties conductrices.

[SOURCE: IEC 60050-195:1998, 195-05-11, modifiée – "par une personne ou un animal d'élevage" remplace "une personne ou un animal"]

3.8.2
tension de contact présumée
tension de toucher présumée
tension apparaissant entre des parties conductrices simultanément accessibles quand ces parties conductrices ne sont pas touchées par une personne ou un animal d'élevage

[SOURCE: IEC 60050-195:1998, 195-05-09, modifiée – "par une personne ou un animal d'élevage" remplace "une personne ou un animal"]

3.9
courant de contact
courant électrique passant dans le corps humain ou dans le corps d'un animal d'élevage lorsque ce corps est en contact avec une ou plusieurs parties accessibles d'une installation ou de matériels

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-05-21, modifiée – "dans le corps d'un animal d'élevage" remplace "dans le corps d'un animal"]

3.10
isolement
ensemble des propriétés qui caractérisent l'aptitude d'une isolation à assurer sa fonction

Note 1 à l'article: Des exemples de propriétés pertinentes sont la résistance, la tension de claquage.

Note 2 à l'article: L'isolement peut être solide, liquide ou gazeux (par exemple l'air), ou une combinaison de ces formes.

[SOURCE: IEC 60050-151:2001, 151-15-42, modifiée – Ajout de Note 2 à l'article]

3.10.1
isolation principale
isolation des parties actives dangereuses qui assure la protection principale

Note 1 à l'article: Cette notion n'est pas applicable à l'isolation utilisée exclusivement à des fins fonctionnelles.

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

3.10.2
isolation supplémentaire
isolation indépendante prévue, en plus de l'isolation principale, en tant que protection en cas de défaut

[SOURCE: IEC 60050-195:1998, 195-06-07]

3.10.3
double isolation
isolation comprenant à la fois une isolation principale et une isolation supplémentaire

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.10.4
isolation renforcée
isolation des parties actives dangereuses assurant une protection contre les chocs électriques équivalente à celle d'une double isolation

Note 1 à l'article: L'isolation renforcée peut comporter plusieurs couches qui ne peuvent pas être soumises à essais séparément en tant qu'isolation principale ou isolation supplémentaire.

[SOURCE: IEC 60050-195:1998, 195-06-09, modifiée – suppression de "assurant un degré..."]

3.11
environnement non conducteur
disposition par laquelle une personne ou un animal d'élevage touchant une partie conductrice accessible qui est devenue une partie active dangereuse est protégée par l'impédance élevée de son environnement (par exemple murs et sols isolants) et par l'absence de parties conductrices mises à la terre

[SOURCE: IEC 60050-195:1998, 195-06-21, modifiée – "animal" remplacé par "animal d'élevage"]

3.12
obstacle de protection (électrique)
élément empêchant un contact fortuit entre un humain ou un animal d'élevage avec une partie active, mais ne s'opposant pas à un tel contact par une action délibérée

[SOURCE: IEC 60050-195:1998, 195-06-16, modifiée – "contact direct" remplacé par "contact" et introduction de "entre un humain ou un animal d'élevage avec une partie active"]

3.13
barrière de protection (électrique)
partie assurant la protection contre les contacts entre un humain ou un animal d'élevage avec une partie active dans toute direction habituelle d'accès

[SOURCE: IEC 60050-195:1998, 195-06-15, modifiée – "contact direct" remplacé par "contact" et introduction de “entre un humain ou un animal d'élevage avec une partie active”]

3.14
enveloppe de protection (électrique)
enveloppe électrique entourant les parties internes des matériels et empêchant, dans toutes les directions, l'accès à une partie active

Note 1 à l'article: De plus, une enveloppe procure généralement une protection contre les influences internes et externes, par exemple entrée de poussière ou d'eau, ou une protection contre les dommages mécaniques.

[SOURCE: IEC 60050-195:1998, 195-06-14, "modifiée – "parties actives dangereuses" remplacé par "une partie active" et ajout de la Note 1 à l'article]

3.15
volume d'accessibilité au toucher
zone s'étendant entre tout point de la surface où les personnes se tiennent et circulent habituellement, et la limite qu'une personne peut atteindre avec la main, dans toutes les directions, sans moyen auxiliaire

[SOURCE: IEC 60050-195:1998, 195-06-12]

3.16
liaison équipotentielle
mise en œuvre de liaisons électriques entre parties conductrices pour réaliser l'équipotentialité

Note 1 à l'article: L'efficacité d'une liaison équipotentielle peut dépendre de la fréquence du courant qui y circule.

[SOURCE: IEC 60050-195:1998, 195-01-10, modifiée – Ajout de la Note 1 à l'article]

3.16.1
liaison équipotentielle de protection
liaison équipotentielle réalisée à des fins de sécurité (par exemple, protection contre les chocs électriques)

Note 1 à l'article: Une liaison équipotentielle fonctionnelle est définie dans l'IEC 60050-195:1998, 195-01-16.

[SOURCE: IEC 60050-195:1998, 195-01-15, modifiée – introduction de “(par exemple, protection contre les chocs électriques)” et ajout de la Note 1 à l'article]

3.16.2
borne d'équipotentialité
borne dont un matériel ou un dispositif est muni, et destinée à être connectée électriquement au réseau de liaison équipotentielle

[SOURCE: IEC 60050-195:1998, 195-02-32]

3.16.3
borne d'équipotentialité de protection
borne destinée à des fins d'équipotentialité de protection

3.16.4
conducteur de protection
conducteur prévu à des fins de sécurité, par exemple protection contre les chocs électriques

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.16.5
conducteur de mise à la terre de protection, PE
conducteur de protection prévu pour réaliser la mise à la terre de protection

[SOURCE: IEC 60050-195:1998, 195-02-11, modifiée – modification de l'intitulé du terme]

3.16.6
conducteur PEN
conducteur assurant à la fois les fonctions de conducteur de mise à la terre de protection et de conducteur de neutre

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

3.16.7
conducteur PEM
conducteur assurant les fonctions de conducteur de mise à la terre de protection et de conducteur de point milieu

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

3.16.8
conducteur PEL
conducteur assurant à la fois les fonctions de conducteur de mise à la terre de protection et de conducteur de ligne

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

3.16.9
conducteur de liaison de protection
conducteur d'équipotentialité
conducteur de protection prévu pour réaliser une liaison équipotentielle de protection

[SOURCE: IEC 60050-195:1998, 195-02-10]

3.16.10
conducteur de ligne
DECONSEILLE: conducteur de phase
conducteur sous tension en service normal et capable de participer au transport ou à la distribution de l'énergie électrique, mais qui n'est ni un conducteur de neutre ni un conducteur de point milieu

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

3.16.11
conducteur (de) neutre
conducteur relié électriquement au point neutre et pouvant contribuer à la distribution de l'énergie électrique

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

3.17
terre
notion qui se réfère à la planète et à toute la matière dont elle est composée

3.17.1
mettre à la terre (verbe)
réaliser une liaison électrique entre la terre locale et un point donné d'un réseau, d'une installation ou d'un matériel

Note 1 à l'article: La liaison à la terre locale peut être:

– intentionnelle; ou
– non intentionnelle; ou
– accidentelle

et peut être permanente ou temporaire.

3.17.2
terre de référence
partie de la Terre considérée comme conductrice, dont le potentiel électrique est pris, par convention, égal à zéro, étant hors de la zone d'influence de toute installation de mise à la terre

[SOURCE: IEC 60050-195:1998, 195-01-01, modifiée – Note supprimée]

3.17.3
terre (locale)
partie de la Terre en contact électrique avec une prise de terre, et dont le potentiel électrique n'est pas nécessairement égal à zéro

[SOURCE: IEC 60050-195:1998, 195-01-03]

3.17.4
prise de terre
électrode de terre
partie conductrice pouvant être incorporée dans un milieu conducteur particulier, par exemple béton ou coke, en contact électrique avec la Terre

[SOURCE: IEC 60050-195:1998, 195-02-01]

3.17.5
conducteur de (mise à la) terre
conducteur assurant un chemin conducteur, ou une partie du chemin conducteur, entre un point donné d'un réseau, d'une installation ou d'un matériel et une prise de terre

[SOURCE: IEC 60050-195:1998, 195-02-03]

3.17.6
installation de mise à la terre
ensemble des liaisons électriques et dispositifs mis en œuvre dans la mise à la terre d'un réseau, d'une installation ou d'un matériel

Note 1 à l'article: Cela peut être une disposition locale limitée de prises de terre interconnectées en haute tension.

[SOURCE: IEC 60050-195:1998, 195-02-20, modifiée – Ajout de la Note 1 à l'article]

3.17.7
mise à la terre pour des raisons de protection
mise à la terre d'un ou plusieurs points d'un réseau, d'une installation ou d'un matériel pour des raisons de sécurité électrique

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-11]

3.17.8
mise à la terre pour des raisons fonctionnelles
mise à la terre d'un ou de plusieurs points d'un réseau, d'une installation ou d'un matériel pour des raisons autres que la sécurité électrique

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-01-13]

3.18
coupure automatique de l'alimentation
interruption d'un ou de plusieurs conducteurs de ligne provoquée par le fonctionnement automatique d'un dispositif de protection en cas de défaut

Note 1 à l'article: Cela ne signifie pas nécessairement l'interruption de tous les conducteurs du réseau d'alimentation.

[SOURCE: IEC 60050-195:1998, 195-04-10, modifiée – "in the event of a fault" remplace "in case of a fault" dans la définition anglaise et ajout de la Note 1 à l'article]

3.19
mesure de protection renforcée
mesure de protection dont la fiabilité n'est pas moindre que celle fournie par deux mesures de protection indépendantes

3.20
écran (conducteur)
partie conductrice qui enveloppe ou sépare des circuits électriques et/ou des conducteurs

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-02-38]

3.21
écran de protection (électrique)
écran conducteur utilisé pour séparer un circuit électrique et/ou des conducteurs des parties actives dangereuses

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-17]

3.22
protection (électrique) par écran
séparation de circuits électriques et/ou de conducteurs par rapport aux parties actives dangereuses par un écran de protection électrique relié au réseau de liaisons équipotentielles de protection et destiné à fournir une protection contre les chocs électriques

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-18]

3.23
séparation simple
séparation entre circuits électriques ou entre un circuit électrique et la terre locale par une isolation principale

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

3.24
séparation de protection (électrique)
séparation entre deux circuits électriques au moyen:

– d'une double isolation; ou
– d'une isolation principale et d'une protection électrique par écran; ou
– d'une isolation renforcée

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-06-19]

3.25
séparation (électrique)
mesure de protection dans laquelle les parties actives dangereuses sont isolées de tous les autres circuits électriques et parties, de la terre locale et de tout contact

[SOURCE: IEC 60050-826:2004, 826-12-27]

3.26
très basse tension
TBT
toute tension ne dépassant pas la valeur maximale de la tension de contact présumée qui peut être maintenue indéfiniment dans des conditions spécifiées d'influences externes

3.26.1
schéma TBTS
schéma électrique dont la tension ne peut pas dépasser la valeur de la très basse tension:

– dans des conditions normales, et
– dans des conditions de premier défaut, y compris des défauts de mise à la terre d'autres circuits électriques

Note 1 à l'article: TBTS est l'abréviation de très basse tension de sécurité.

[SOURCE: IEC 60050-826:2004, 826-12-31, modifiée – "premier défaut" remplace "défaut simple"]

3.26.2
schéma TBTP
schéma électrique dont la tension ne peut pas dépasser la valeur de la très basse tension:

– dans des conditions normales, et
– dans des conditions de premier défaut, à l'exception des défauts à la terre dans les autres circuits électriques

Note 1 à l'article: TBTP est l'abréviation de très basse tension de protection.

[SOURCE: IEC 60050-826:2004, 826-12-32, modifiée – "premier défaut" remplace "défaut simple"]

3.27
protection par limitation du courant de contact en régime établi et de la charge électrique
protection contre les chocs électriques assurée par la conception des circuits ou des matériels (électriques), de telle façon que le courant en régime établi et la charge électrique soient limités au-dessous d'une valeur dangereuse, dans les conditions normales ou de défaut

[SOURCE: IEC 60050-826:2004, 826-12-34, modifiée – "courant permanent" remplacé par "courant de contact en régime établi"]

3.28
source à courant limité
appareil qui fournit de l'énergie électrique à un circuit électrique

– avec une séparation de protection vis-à-vis des parties actives dangereuses, et
– assurant que le courant de contact en régime établi et la charge sont limités à des niveaux non dangereux en fonctionnement normal ou dans des conditions de défaut

3.29
dispositif d'impédance de protection
composant ou ensemble de composants dont l'impédance et la conception limitent le courant de contact en régime établi et la charge à des niveaux non dangereux

[SOURCE: IEC 60050-826:2004, 826-12-35, modifiée – suppression de "sont telles qu'elles assurent la limitation ..."]

3.30
personne qualifiée (en électricité)
personne ayant la formation et l'expérience appropriées pour lui permettre de percevoir les risques et d'éviter les dangers que peut présenter l'électricité

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-04-01]

3.31
personne avertie (en électricité)
personne suffisamment informée ou surveillée par des personnes qualifiées en électricité pour lui permettre de percevoir les risques et d'éviter les dangers que peut présenter l'électricité

[SOURCE: IEC 60050-195:1998/AMD1:2001, 195-04-02]

3.32
personne ordinaire
personne qui n'est ni une personne qualifiée ni une personne avertie

[SOURCE: IEC 60050-195:1998, 195-04-03]

3.33
tension de pas
tension entre deux points de la surface de la Terre distants de 1 m

Note 1 à l'article: Cette distance de 1 m est considérée comme la longueur de l'enjambée d'une personne.

[SOURCE: IEC 60050-195:1998, 195-05-12, modifiée – suppression de "ce qui est considéré comme la longueur de l'enjambée d'une personne'' et ajout de la Note 1 à l'article]

3.34
gradient de potentiel
contrôle du potentiel de la terre, plus particulièrement celui de la surface de la terre, au moyen de prises de terre

3.35
zone dangereuse
dans le cas de la haute tension, zone limitée par une distance minimale autour des parties actives dangereuses ne présentant pas une protection complète

Note 1 à l'article: L'entrée dans une zone dangereuse est considérée comme équivalente au contact avec des parties actives dangereuses.

3.36
courant de fuite
courant électrique qui, dans des conditions normales, s'écoule à travers un chemin électrique non prévu

[SOURCE: IEC 60050-195:1998, 195-05-15, modifiée – "non prévu" remplace "non désiré"]

3.37
matériel semi-fixe
matériel stationnaire
matériel installé à poste fixe ou matériel électrique non muni d'une poignée pour le transport et ayant une masse telle qu'il ne puisse pas être déplacé facilement

Note 1 à l'article: Cette masse est fixée à 18 kg au minimum dans les normes CEI relatives aux appareils électrodomestiques.

[SOURCE: IEC 60050-826:2004, 826-16-06, modifiée – "au minimum" ajoutée à la Note 1 à l'article]

3.38
courant dans le conducteur de protection
courant électrique apparaissant dans un conducteur de protection, tel que courant de fuite ou courant électrique dû à un défaut d'isolation

[SOURCE: IEC 60050-826:2004, 826-11-21]

3.39
système
ensemble d'éléments reliés entre eux, considéré comme un tout dans un contexte défini et séparé de son environnement

[SOURCE: IEC 60050-351:2013, 351-42-08, modifiée – Notes supprimées]

3.40
installation (électrique)
ensemble de matériels électriques associés ayant des caractéristiques coordonnées en vue d'une application donnée

[SOURCE: IEC 60050-826:2004, 826-10-01]

3.41
sectionnement
fonction destinée à assurer la mise hors tension et le maintien à une distance adéquate de toute source d'énergie électrique, pour des raisons de sécurité

3.42
tension de tenue aux chocs
valeur de crête d'une tension de choc, de forme et de polarité prescrites, qui ne provoque pas de claquage dans des conditions d'essai spécifiées

3.43
brûlure électrique
brûlure de la peau ou d'un organe, causée par le passage superficiel ou en profondeur d'un courant électrique

[SOURCE: IEC 60050-195:1998, 195-03-01]

3.44
mesure de protection
mesure indépendante destinée à assurer la protection contre les chocs électriques dans des conditions spécifiées

Note 1 à l'article: La mesure peut être un moyen, une technique, un dispositif ou un processus.

3.45
mesure de prévention
combinaison appropriée de mesures de protection pour la protection contre les chocs électriques

4 Règle fondamentale de protection contre les chocs électriques

4.1 Généralités

Un choc électrique est défini comme un effet physiologique résultant d'un courant électrique passant dans le corps humain ou le corps d'un animal d'élevage. L'effet physiologique peut être nuisible (par exemple, fibrillation ventriculaire, brûlures, asphyxie), voir 4.2 à 4.5, ou non nuisible (par exemple, réaction musculaire, perception), voir 4.6.

Les parties actives dangereuses ne doivent pas être accessibles et les parties conductrices accessibles ne doivent pas être dangereuses:

– ni dans les conditions normales (fonctionnement selon l'utilisation prévue, voir 3.6 du Guide ISO/IEC 51:2014, et absence de défaut),
– ni dans des conditions de premier défaut.

NOTE Les règles d'accessibilité pour les personnes ordinaires peuvent être différentes de celles pour les personnes qualifiées ou averties et peuvent aussi varier selon les produits et les emplacements.

Pour les installations, les systèmes et les matériels à haute tension, l'entrée dans une zone dangereuse est considérée comme équivalente au contact avec des parties actives dangereuses.

La protection dans des conditions normales (voir 4.2) est assurée par une protection principale. La protection dans des conditions de premier défaut (voir 4.3) est assurée par une protection en cas de défaut. La protection complémentaire est spécifiée comme faisant partie d'une mesure de prévention (voir 4.4), le cas échéant.

Les mesures de protection renforcée (voir 4.3.3) assurent la protection dans les types de conditions normales et de premier défaut.

4.2 Conditions normales

Afin de satisfaire à la règle fondamentale de protection contre les chocs électriques dans des conditions normales, une protection principale, comme spécifié dans la présente norme, est nécessaire.

Les exigences relatives aux mesures de protection principale sont données en 5.2.

Afin de définir les exigences pour les installations et matériels, les bandes suivantes sont spécifiées:

- Haute tension (HT)

  lorsque la protection contre les chocs électriques est garantie par des mesures spéciales, en particulier des installations de mise à la terre.

- Basse tension (BT)

lorsque la protection contre les chocs électriques est garantie par une protection principale et en général également une protection en cas de défaut.

La très basse tension (TBT) fait partie de la bande BT.

Lorsque la TBT est appliquée, la protection en cas de défaut peut ne pas être nécessaire, et dans certaines conditions, une protection principale est fournie avec limitation de tension. Ces conditions incluent la zone de contact, l'humidité, la tension, le courant et autres conditions définies pour des applications particulières.

Le Tableau 1 spécifie les différentes limites de tension pour les bandes mentionnées ci-dessus.

Les valeurs dans le Tableau 1 sont basées sur les conditions suivantes:

- réseaux à courant alternatif:
  - pour les réseaux mis à la terre par les valeurs efficaces des tensions entre phase et terre et entre phases;
  - pour les réseaux isolés ou non efficacement mis à la terre, par la valeur efficace de la tension entre phases.
- réseaux à courant continu:
  - pour les réseaux mis à la terre par les valeurs des tensions entre phase et terre et entre phases;
  - pour les réseaux isolés ou non efficacement mis à la terre, par la valeur de la tension entre phases.

Tableau 1 – Limites pour bandes de tension

Bande de tension		courant alternatif	courant continu
HT		> 1 000 V	> 1 500 V
BT		≤ 1 000 V	≤ 1 500 V
	TBT	≤ 50 V	≤ 120 V

La limite supérieure de la TBT de 120 V en courant continu a été définie pendant de nombreuses années par convention. Cependant, différentes situations environnementales et de contact comme décrit dans l'IEC TS 60479-1 entraînent différentes valeurs de courant de contact, pour une tension donnée. De même, la forme du courant et le chemin parcouru dans le corps influencent fortement le niveau de danger. Par conséquent, il est demandé aux comités d'études de considérer très attentivement si une valeur TBT inférieure à 120 V en courant continu peut être nécessaire pour leur norme spécifique.

4.3 Conditions de premier défaut

4.3.1 Généralités

Les premiers défauts doivent être considérés si

– une partie active accessible, non dangereuse est devenue une partie active dangereuse (par exemple, en raison d'une défaillance de la limitation du courant de contact en régime établi et de la charge électrique), ou si

– une partie conductrice accessible qui n'est pas sous tension dans des conditions normales est devenue une partie active dangereuse (par exemple, en raison d'une défaillance entre l'isolation principale et les masses), ou si

– une partie active dangereuse est rendue accessible (par exemple, par défaillance mécanique d'une enveloppe).

Pour satisfaire à la règle fondamentale dans des conditions de premier défaut, une protection en cas de défaut est nécessaire, et dans certains cas une protection complémentaire. Cette protection peut être réalisée par

– une mesure de protection complémentaire, indépendante de la mesure de protection principale (voir 4.3.2), ou
– une mesure de protection renforcée (voir 4.3.3) qui assure à la fois une protection principale et une protection en cas de défaut,

en prenant en compte toutes les influences appropriées.

Des exigences relatives aux mesures de protection en cas de défaut sont données en 5.3.

4.3.2 Protection par des mesures de protection indépendantes

Chacune des mesures de protection indépendantes doit être conçue de manière qu'une défaillance ne soit pas susceptible de se produire dans les conditions spécifiées par le comité d'études approprié.

Les mesures de protection indépendantes ne doivent pas avoir d'influence l'une sur l'autre de manière que la défaillance de l'une puisse rendre l'autre inopérante.

La défaillance simultanée des mesures de protection indépendantes est improbable et il n'est normalement pas nécessaire de la prendre en compte. La confiance repose sur les mesures de protection non affectées demeurant effectives.

4.3.3 Protection par une mesure de protection renforcée

Les propriétés d'une mesure de protection renforcée doivent être telles que l'efficacité de cette protection soit la même que celle réalisée par deux mesures de protection indépendantes. Les exigences pour des mesures de protection renforcée sont données en 5.4.

4.4 Protection complémentaire

Si l'utilisation prévue implique un risque inhérent accru, par exemple, pour des emplacements présentant un contact à faible impédance des personnes avec le potentiel de terre, les comités d'études doivent considérer la nécessité éventuelle de spécifier une protection complémentaire. Une telle protection complémentaire peut être prévue dans l'installation, le système ou le matériel.

Les exigences relatives à la protection complémentaire sont données en 5.5.

Les conditions de premier défaut résultant d'une ou plusieurs défaillances consécutives doivent être considérées comme condition de premier défaut.

4.5 Protection contre les brûlures électriques

Les comités d'études doivent définir dans leurs normes des mesures pour assurer une protection contre les brûlures électriques.

Une brûlure électrique peut être provoquée lorsqu'un courant d'une densité et d'une durée suffisantes traverse le corps humain ou un animal d'élevage. Les arcs peuvent également provoquer des brûlures.

Les effets peuvent être graves même si uniquement une partie infime du corps est touchée.

NOTE 1 Des brûlures profondes et autres blessures internes, ou brûlures en surface peuvent se produire.

NOTE 2 Des informations techniques sur les brûlures électriques peuvent être consultées dans l'IEC TS 60479-1 et la technique de mesure peut être consultée dans l'IEC 60990 pour de nombreux cas.

4.6 Protection contre les effets physiologiques sans effet nocif pour la santé

4.6.1 Généralités

Les comités d'études doivent considérer si les effets suivants doivent être pris en compte dans leurs normes.

Le courant circulant dans le corps humain sans avoir d'effet nocif direct peut provoquer des situations qui sont peu pratiques ou dangereuses (par exemple, résultats d'une réaction de tressaillement).

Ceci peut concerner le seuil de perception ou le seuil de douleur ou la sensation de chaleur.

4.6.2 Réaction musculaire

Les contractions musculaires involontaires sont susceptibles de se produire, lorsque les courants traversant le corps humain ou un animal d'élevage circulent dans la plage des zones AC-2 des zones de temps/courant, pour le courant alternatif 15 Hz à 100 Hz, et dans la plage des zones DC-2 des zones de temps/courant, pour le courant continu conformément à l'IEC TS 60479-1.

Pour le courant alternatif avec une fréquence inférieure à 100 Hz ou pour un courant continu avec ondulation ne dépassant pas 10 %, le seuil de tension de contact pour réaction ne doit pas dépasser les valeurs données dans le Tableau 2.

Tableau 2 – Seuils de tension de contact pour réaction

Type de réaction	Seuil de tension
Réaction de tressaillement	2 V en courant alternatif ou 8 V en courant continu
Réaction musculaire	20 V en courant alternatif ou 40 V en courant continu

Ces valeurs du Tableau 2 sont définies pour des conditions sèches et une zone de contact de 35 cm^2.

Si d'autres conditions d'environnement telles que imbibé d'eau salée, imbibé d'eau ou immergé, sont considérées, ces valeurs peuvent être réduites, en fonction également du chemin parcouru par le courant dans le corps.

4.6.3 Effets du courant de contact de décharge des charges électrostatiques

Les réactions de tressaillement sont susceptibles de se produire lorsque les courants résultant d'une décharge électrostatique circulent dans le corps humain ou un animal d'élevage.

4.6.4 Effets thermiques

Une sensation de chaleur peut être observée, lorsque même de faibles valeurs de courant circulent dans le corps humain ou un animal d'élevage. L'effet peut être plus évident à des fréquences plus élevées.

Des effets comme l'augmentation de la pression artérielle, l'immobilisation, les troubles de formation et la conduction d'impulsions cardiaques (notamment les troubles de fibrillation auriculaire et de rythme transitoire) peuvent se produire.

5 Mesures de protection (éléments de mesures de prévention)

5.1 Généralités

Les Paragraphes 5.2 à 5.5 donnent une vue d'ensemble des différentes mesures de protection. Les mesures de prévention résultent d'une combinaison appropriée d'entre elles. La structure des mesures de prévention types est décrite dans l'Article 6.

Toutes les mesures de protection doivent être conçues et construites pour être effectives pendant la durée de vie anticipée de l'installation, du système ou du matériel lorsqu'ils sont utilisés de manière prévue et entretenus de manière appropriée.

L'environnement doit être pris en compte en utilisant la classification des influences externes décrites dans la série IEC 60721 et pour les essais, dans la série IEC 60068. L'attention est particulièrement attirée sur la température ambiante, les conditions climatiques, la présence d'eau, les contraintes mécaniques, la compétence des personnes et la surface de contact des personnes ou des animaux d'élevage avec le potentiel de terre.

Les comités d'études doivent prendre en compte les exigences relatives à la coordination de l'isolement. Pour les installations, les systèmes et les matériels à basse tension, ces exigences sont définies dans la série IEC 60664 qui donne aussi des règles pour le dimensionnement des distances d'isolement (dans l'air) et des lignes de fuite, ainsi que des lignes directrices de dimensionnement de l'isolation solide. Pour les installations, systèmes et matériels à haute tension, les exigences sont données dans l'IEC 60071-1 et l'IEC 60071-2.

5.2 Mesures pour la protection principale

5.2.1 Généralités

La protection principale doit comprendre une ou plusieurs mesures qui, dans des conditions normales, empêchent tout contact avec les parties actives dangereuses.

NOTE Les peintures, vernis, laques et produits analogues ne sont en général pas considérés comme constituant une isolation suffisante pour la protection contre les chocs électriques en utilisation normale.

Les Paragraphes 5.2.2 à 5.2.9 spécifient des mesures individuelles pour la protection principale.

5.2.2 Isolation principale

5.2.2.1 Lorsqu'une isolation principale solide est utilisée, elle doit empêcher tout contact avec des parties actives dangereuses.

En cas d'installations et de matériels à haute tension, une tension peut être présente à la surface de l'isolation solide et des précautions supplémentaires doivent être considérées.

5.2.2.2 Lorsque l'isolation principale est assurée par l'air, l'accès aux parties actives dangereuses ou à une zone dangereuse doit être empêché par des obstacles, des barrières ou des enveloppes de protection comme spécifié en 5.2.3 et 5.2.4, ou par mise hors de volume d'accessibilité au toucher comme spécifié en 5.2.5.

5.2.3 Barrières ou enveloppes de protection

5.2.3.1 Les barrières ou les enveloppes de protection doivent empêcher:

– dans le cas des installations et matériels à basse tension, l'accès aux parties actives dangereuses en assurant un degré de protection contre les chocs électriques d'au moins IPXXB ou IP2X de l'IEC 60529 et, pour les surfaces supérieures horizontales facilement accessibles des barrières ou des enveloppes de protection, un degré de protection d'au moins IPXXD ou IP4X

– dans le cas des installations et matériels à haute tension, l'accès à une zone dangereuse en assurant un degré de protection d'au moins IPXXB ou IP2X de l'IEC 60529, et il doit être considéré d'assurer un degré de protection d'au moins IPXXD ou IP4X pour les surfaces supérieures horizontales facilement accessibles des barrières ou des enveloppes de protection.

NOTE Le code IP s'applique aux enveloppes du matériel électrique dont la tension assignée ne dépasse pas 72,5 kV.

5.2.3.2 Les barrières ou les enveloppes de protection doivent présenter une tenue mécanique, une stabilité et une durabilité suffisantes pour maintenir le degré spécifié de protection, en tenant compte de toutes les influences appropriées internes et externes à l'enveloppe. Elles doivent être solidement fixées.

5.2.3.3 Lorsque la conception ou la construction permet l'enlèvement des barrières de protection, l'ouverture des enveloppes ou l'enlèvement de parties des enveloppes, l'accès aux parties actives dangereuses ou à une zone dangereuse ne doit être possible que dans les conditions suivantes:

– usage d'une clé ou d'un outil, ou

– lorsque, après interruption de l'alimentation des parties actives dangereuses et lorsque l'enveloppe n'assure plus la protection, le rétablissement de l'alimentation ne doit être possible qu'après la remise en place des barrières de protection ou des parties des enveloppes ou la fermeture de portes, ou

– lorsqu'une barrière intermédiaire maintient le degré de protection exigé, elle ne peut être enlevée qu'à l'aide d'une clé ou d'un outil.

NOTE Voir aussi l'Article 8.

5.2.4 Obstacles

5.2.4.1 Les obstacles sont destinés à protéger les personnes qualifiées ou averties, mais il n'est pas admis de les utiliser pour protéger les personnes ordinaires.

5.2.4.2 Lors du fonctionnement de l'installation, du système ou du matériel dans des conditions particulières de fonctionnement et d'entretien (voir Article 8), les obstacles doivent empêcher:

– dans le cas d'installations et de matériels à basse tension, tout contact non intentionnel avec des parties actives dangereuses, ou

– dans le cas d'installations et de matériels à haute tension, tout accès non intentionnel à une zone dangereuse.

5.2.4.3 Les obstacles peuvent être démontables sans l'aide d'une clé ou d'un outil; ils doivent cependant être fixés de manière à empêcher tout enlèvement involontaire.

5.2.4.4 Lorsqu'un obstacle conducteur n'est séparé des parties actives dangereuses que par une isolation principale, il est considéré comme une masse et des mesures de protection en cas de défaut (voir Article 6) doivent également être prises.

5.2.5 Mise hors de volume d'accessibilité au toucher

5.2.5.1 Lorsque les mesures spécifiées en 5.2.2, 5.2.3, 5.2.4, 5.2.6 et 5.2.7 s'avèrent non applicables, la mise hors du volume d'accessibilité au toucher peut être appropriée pour empêcher

– dans le cas d'installations et de matériels à basse tension, un accès non intentionnel et simultané à des parties conductrices entre lesquelles une tension dangereuse peut apparaître,

– dans le cas d'installations et de matériels à haute tension, tout accès non intentionnel à une zone dangereuse.

Des indications doivent être spécifiées par les comités d'études.