BS EN 61140:2016

BSI Standards Publication

Protection against electric shock — Common aspects for installation and equipment

bsi.

National foreword

This British Standard is the UK implementation of EN 61140:2016. It is identical to IEC 61140:2016. It supersedes BS EN 61140:2002+A1:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee JPEL/64, Electrical installations of buildings - Joint committee.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61140

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Supersedes EN 61140:2002

English Version

Protection against electric shock - Common aspects for installation and equipment (IEC 61140:2016)

Protection contre les chocs électriques - Aspects communs aux installations et aux matériels (IEC 61140:2016)

Schutz gegen elektrischen Schlag - Gemeinsame Anforderungen für Anlagen und Betriebsmittel (IEC 61140:2016)

This European Standard was approved by CENELEC on 2016-02-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 64/2076/FDIS, future edition 4 of IEC 61140, prepared by IEC/TC 64 "Electrical installations and protection against electric shock" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61140:2016.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-11-27
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-05-27

This document supersedes EN 61140:2002.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Endorsement notice

The text of the International Standard IEC 61140:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60364-4-41:2005	NOTE	Harmonized as HD 60364-4-41:2007 (modified).
IEC 60364-4-44:2007	NOTE	Harmonized as HD 60364-4-442:2012 (modified) and as HD 60364-4-444:2010 (modified).
IEC 60364-6:2006	NOTE	Harmonized as HD 60364-6:2007 (modified).
IEC 60601-1	NOTE	Harmonized as EN 60601-1.
IEC 61558-2-6	NOTE	Harmonized as EN 61558-2-6.
IEC 61936-1	NOTE	Harmonized as EN 61936-1.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60038	-	IEC standard voltages	EN 60038	-
IEC 60068	series	Environmental testing	EN 60068	series
IEC 60071-1	-	Insulation co-ordination - Part 1: Definitions, principles and rules	EN 60071-1	-
IEC 60071-2	-	Insulation co-ordination - Part 2: Application guide	EN 60071-2	-
IEC 60364-5-54	2011	Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective conductors	HD 60364-5-54	2011
IEC 60417	-	Graphical symbols for use on equipment	-	-
IEC 60445	-	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors	EN 60445	-
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 enclosures (IP Code)	EN 60529	-
IEC 60664	series	Insulation coordination for equipment within low-voltage systems	EN 60664	series
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007

Publication	Year	Title	EN/HD	Year
IEC 60721	series	Classification of environmental conditions	EN 60721	series
IEC 60990	-	Methods of measurement of touch current and protective conductor current	EN 60990	-
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	EN 62271-102	-
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	-	-

CONTENTS

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.

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.

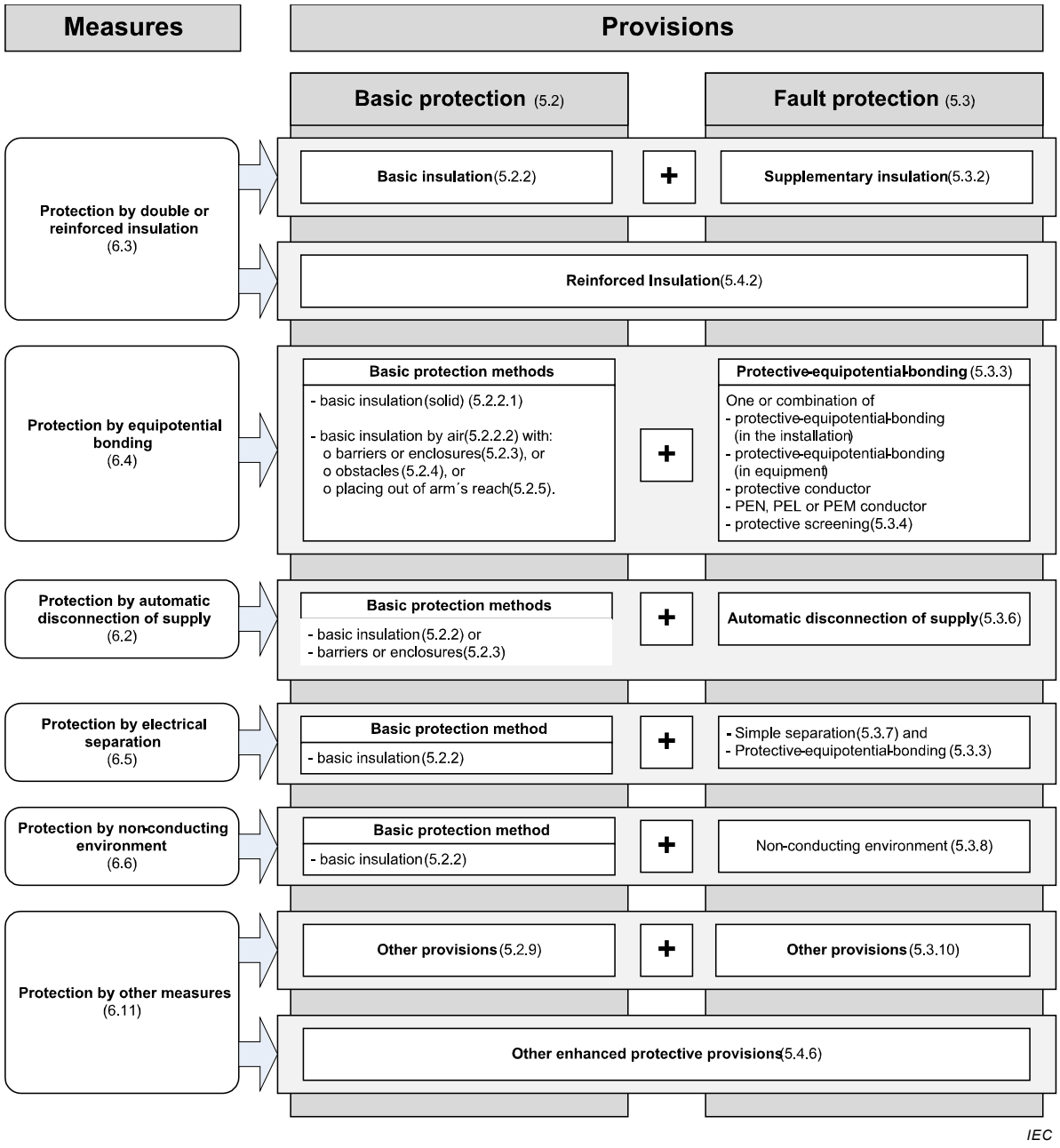

Figure A.1 – Protective measures with basic and fault protection

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

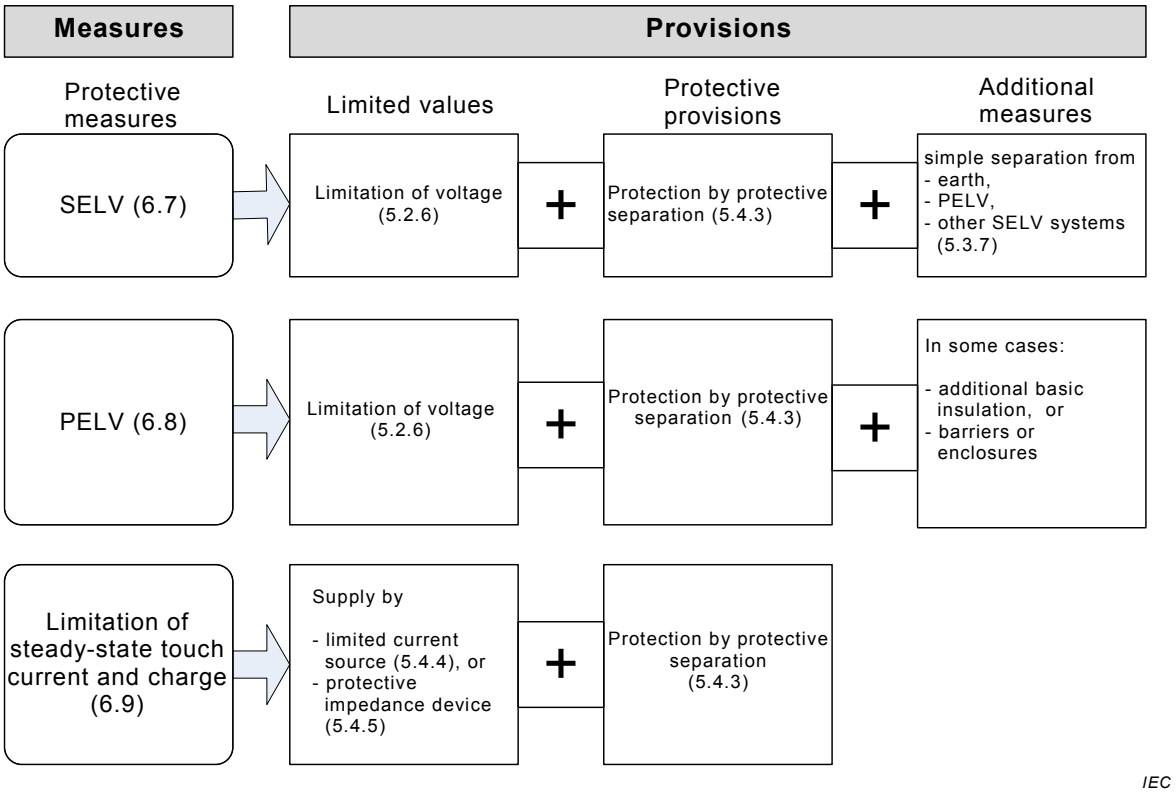

Figure A.2 – Protective measures with limited values of electrical quantities

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

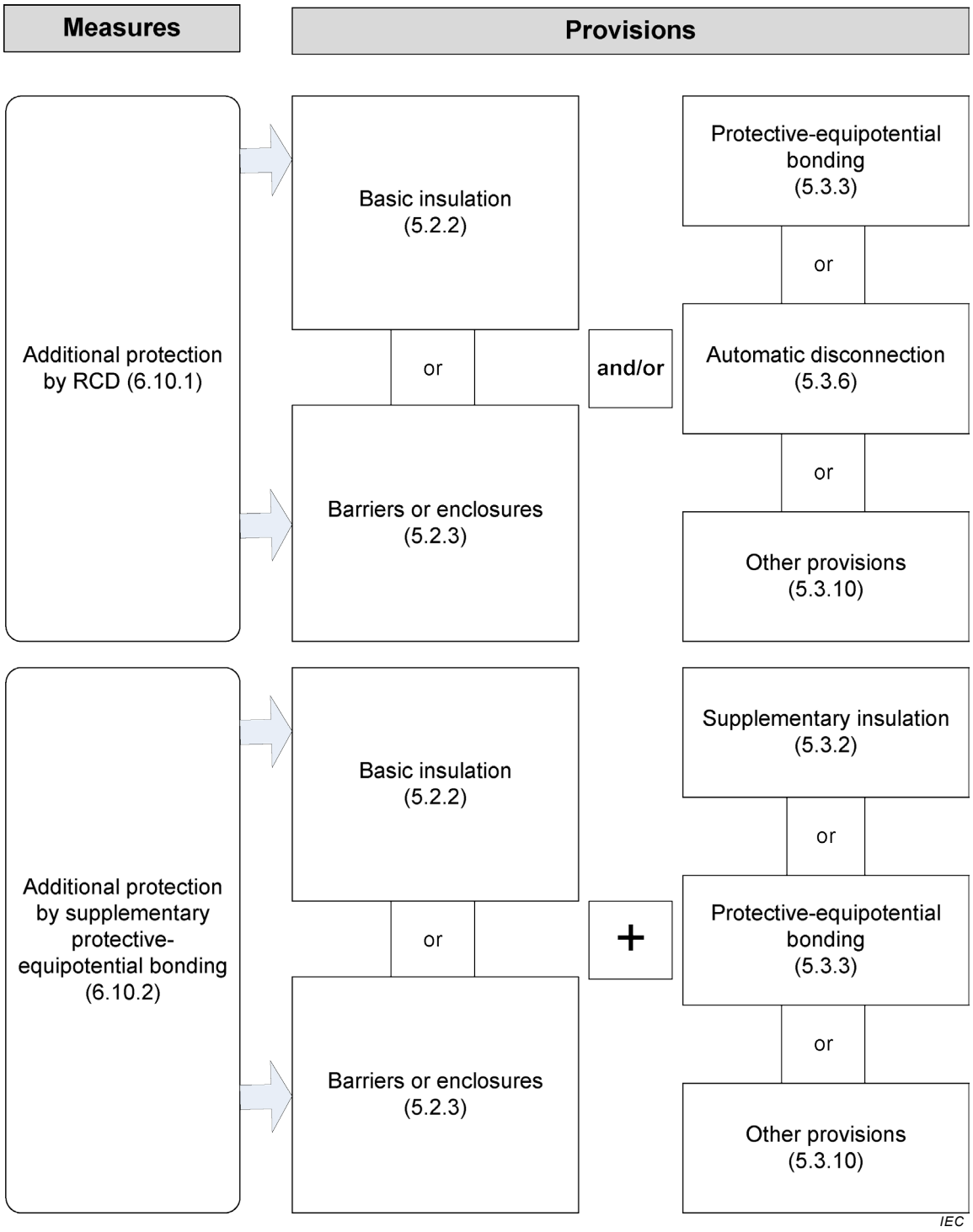

Figure A.3 – Protective measure: additional protection (in addition to basic and/or fault protection)

Annex B
(informative)

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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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