# IEC 61140

Edition 3.1 2009-09

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

## Protection against electric shock – Common aspects for installation and equipment

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

IEC 61140:2001+A1:2004

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## Protection against electric shock – Common aspects for installation and equipment

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATION AND EQUIPMENT

## FOREWORD

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International Standard IEC 61140 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This consolidated version of IEC 61140 consists of the third edition (2001) [documents 64/1191/FDIS and 64/1202/RVD] and its amendment 1 (2004) [documents 64/1402/FDIS and 64/1412/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 3.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

Annexes A, B and C are for information only.

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The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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# INTRODUCTION

This International Standard is a Basic Safety Publication intended for use by technical committees in the preparation of standards in accordance with the principles of IEC Guide 104 and ISO/IEC Guide 51.

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# PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATION AND EQUIPMENT

## 1 Scope

This International Standard applies to the protection of persons and animals against electric shock. It is intended to give fundamental principles and requirements which are common to electrical installations, systems and equipment or necessary for their co-ordination.

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

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

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

## 2 Normative references

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

IEC 60038:1983, *IEC standard voltages*

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

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

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

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

IEC 60071-1:1993, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

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

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

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

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

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

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

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

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

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

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

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

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

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

IEC 61201:1992, *Extra-low-voltage (ELV) – Limit values*

IEC 62271-102:2001, *High-voltage switchgear and controlgear – Part 102 : Alternating current disconnectors and earthing switches*

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

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

## 3 Definitions

NOTE An index of definitions is given in annex C.

For the purpose of this International Standard the following definitions apply:

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

[IEV 195-01-04]

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

[IEV 195-06-01]

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

**3.1.2**
**fault protection**
protection against electric shock under single-fault conditions

[IEV 195-06-02]

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

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

[IEV 131-01-01]

NOTE See also IEV 826-05-01 for electrical installations of buildings.

**3.3**
**(electrical) equipment**
any item used for such purposes as generation, conversion, transmission, storage, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, accessories for wiring systems, appliances

[IEV 826-07-01, modified]

**3.4**
**live part**
conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

[IEV 195-02-19]

NOTE 1 This concept does not necessarily imply a risk of electric shock.

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

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

[IEV 195-06-05]

NOTE 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.

**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

[IEV 195-06-10]

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.

**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

[IEV 195-06-11]

**3.8**
**touch voltage**

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

NOTE The value of the effective touch voltage may be appreciably influenced by the impedance of the person or the animal in electric contact with these conductive parts.

[IEV 195-05-11]

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

[IEV 195-05-09]

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

[IEV 195-05-21]

**3.10**
**insulation**

NOTE Insulation can be a solid, a liquid or a gas (e.g. air), or any combination.

**3.10.1**
**basic insulation**
insulation of hazardous-live-parts which provides basic protection

NOTE This concept does not apply to insulation used exclusively for functional purposes.

[IEV 195-06-06]

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

[IEV 195-06-07]

**3.10.3**
**double insulation**
insulation comprising both basic insulation and supplementary insulation

[IEV 195-06-08]

**3.10.4**
**reinforced insulation**
insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

NOTE Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

[IEV 195-06-09]

**3.11**
**non-conducting environment**
provision whereby a person or an animal 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

[IEV 195-06-21]

**3.12**
**(electrically) protective obstacle**
part preventing unintentional direct contact, but not preventing direct contact by deliberate action

[IEV 195-06-16]

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

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**3.13**
**(electrically) protective barrier**
part providing protection against direct contact from any usual direction of access

[IEV 195-06-15]

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

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

[IEV 195-06-14]

NOTE In addition, an enclosure generally provides protection against internal or external influences, e.g. ingress of dust or water or prevention of mechanical damage.

**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

[IEV 195-06-12]

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

[IEV 195-01-10 ]

NOTE The effectiveness of the equipotential bonding may depend on the frequency of the current in the bonding.

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

[IEV 195-01-15, modified]

NOTE Functional equipotential bonding is defined in IEV 195-01-16.

**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

[IEV 195-02-32]

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

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

[IEV 195-02-09]

**3.16.5**
**PEN conductor**
conductor combining the functions of both protective conductor and neutral conductor

[IEV 195-02-12, modified]

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**3.17**
**earth**

NOTE The concept "Earth" means the planet and all its physical matter

**3.17.1**
**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

[IEV 195-01-01]

**3.17.2**
**(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

[IEV 195-01-03]

**3.17.3**
**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

[IEV 195-02-01]

**3.17.4**
**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

[IEV 195-02-03]

**3.17.5**
**earthing arrangement**
**grounding arrangement (US)**
all the electric connections and devices involved in the earthing of a system, an installation and equipment

[IEV 195-02-20]

NOTE This could be a locally limited arrangement of interconnected earth electrodes on the high-voltage side.

**3.17.6**
**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

[IEV 195-01-11]

**3.17.7**
**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

[IEV 195-01-13]

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**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 case of a fault

[IEV 195-04-10]

NOTE This does not necessarily mean an interruption in all conductors of the supply system.

**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

[IEV 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

[IEV 195-06-17]

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

[IEV 195-06-18]

**3.23**
**simple separation**
separation between circuits or between a circuit and earth by means of basic insulation

**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

[IEV 195-06-19]

**3.25**
**electrical separation**
protective measure in which a circuit that is hazardous-live is insulated from all other circuits and parts, from earth and from touch

**3.26**
**extra-low-voltage (ELV)**
any voltage not exceeding the relevant voltage limit specified in IEC 61201

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**3.26.1**
**SELV system**
an electrical system in which the voltage cannot exceed ELV:

– under normal conditions; and

– under single-fault conditions, including earth faults in other circuits

**3.26.2**
**PELV system**
an electrical system in which the voltage cannot exceed ELV:

– under normal conditions, and

– under single-fault conditions, except earth faults in other circuits

**3.27**
**limitation of steady-state touch current and charge**
protection against electric shock by circuit or equipment design such that under normal and fault conditions the steady-state touch current and charge are limited to non-hazardous levels

[IEV 826-03-16, modified]

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

– with protective-separation from hazardous-live-parts, and

– which ensures that the steady-state touch current and charge are limited to non-hazardous levels, under normal and fault conditions

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

**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

[IEV 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

[IEV 195-04-02]

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

[IEV 195-04-03]

**3.33**
**step voltage**
voltage between two points on the earth's surface that are 1 m distant from each other, which is considered to be the stride length of a person

[IEV 195-05-12]

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

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

NOTE Entering the danger zone is considered the same as touching hazardous-live-parts.

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

[IEV 195-05-15]

**3.37**
**stationary equipment**
– fixed equipment, or
– permanently connected equipment, or
– equipment that, due to its physical characteristics, is normally not moved and is normally plugged into the same socket-outlet

**3.38**
**protective conductor current**
current which flows in a protective conductor

(see 3.2 of IEC 60990)

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

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

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

[IEV 351-11-01]

**3.40**
**(electrical) installation**
an assembly of associated electrical equipment to fulfil a specific purpose or purposes and having co-ordinated characteristics

[IEV 826-01-01]

**3.41**
**isolation**
function intended to make dead for reasons of safety all or a discrete section of the electrical installation by separating the electrical installation or section from every source of electric energy

[IEV 826-08-01]

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

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## 4 Fundamental rule of protection against electric shock

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 3.13 of ISO/IEC Guide 51, and absence of a fault), or

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

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

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

Protection under normal conditions (see 4.1) is provided by basic protection, and protection under single-fault conditions (see 4.2) is provided by fault protection.

Enhanced protective provisions (see 4.2.2) provide protection under both conditions.

### 4.1 Normal conditions

To meet the fundamental rule for protection against electric shock under normal conditions, what is referred to in this standard as basic protection is necessary. The requirements for provisions for basic protection are given in 5.1.

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

### 4.2 Single-fault conditions

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 of limitation of steady-state touch current and charge), or

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

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

To meet the fundamental rule under single-fault conditions, what is referred to in this standard as fault protection is necessary. This protection can be achieved by

– a further protective provision, independent of that for basic protection (see 4.2.1), or

– an enhanced protective provision (see 4.2.2) which provides both basic and fault protection

taking account of all relevant influences.

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

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

#### 4.2.1 Protection by two independent protective provisions

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

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

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

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

#### 4.2.2 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 5.3.

### 4.3 Special cases

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

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

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

## 5 Protective provisions (elements of protective measures)

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

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

Technical committees shall take account of the requirements for insulation co-ordination. For low-voltage installations, systems and equipment these requirements are found in IEC 60664-1 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.

### 5.1 Provisions for basic protection

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 5.1.1 to 5.1.8 specify some individual provisions for basic protection.

#### 5.1.1 Basic insulation

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

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

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**5.1.1.2** Where basic insulation is provided by air, access to hazardous-live-parts or entering the danger zone shall be prevented by obstacles, barriers or enclosures as specified in 5.1.2 and 5.1.3 or by placing out of arm's reach as specified in 5.1.4.

### 5.1.2 Barriers or enclosures

**5.1.2.1** Barriers or enclosures shall prevent

- in the case of low-voltage installations and equipment, access to hazardous-live-parts by providing a degree of protection against electric shock of at least IPXXB (also complied with by IP2X) of IEC 60529,
- in the case of high-voltage installations and equipment, entering the danger zone by providing a degree of protection of at least IPXXB (also complied with by IP2X) of IEC 60529.

**5.1.2.2** 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.

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

– 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 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.

### 5.1.3 Obstacles

**5.1.3.1** Obstacles are intended to protect skilled or instructed persons but are not intended to protect ordinary persons.

**5.1.3.2** 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.

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

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

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### 5.1.4 Placing out of arm's reach

**5.1.4.1** Where provisions specified in 5.1.1.1, 5.1.2, 5.1.3, 5.1.5 and 5.1.6 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 the danger zone.

Details shall be specified by technical committees.

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

**5.1.4.2** 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 parts between which a hazardous voltage can exist.

### 5.1.5 Limitation of voltage

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

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

### 5.1.6 Limitation of steady-state touch current and charge

Limitation of steady-state touch current and charge shall prevent persons or animals from being subjected to values of steady-state touch current and charge liable to be hazardous or perceptible.

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

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

– Values not exceeding the threshold of pain a.c. 3,5 mA or d.c. 10 mA may be specified.

– A stored charge available between simultaneously accessible conductive parts not exceeding 0,5 µC (threshold of perception) is recommended, and 50 µC (threshold of pain) may be specified.

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

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

– Medical electrical equipment within the scope of IEC 60601 may necessitate other levels.

### 5.1.7 Potential grading

In the case of high-voltage installations and equipment, potential grading shall prevent persons or animals 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, where high earth currents occur.

### 5.1.8 Other provisions

Any other provision for basic protection shall comply with the fundamental rule (see clause 4).

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### 5.2 Provisions for fault protection

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

Subclauses 5.2.1 to 5.2.8 specify individual provisions for fault protection.

#### 5.2.1 Supplementary insulation

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

#### 5.2.2 Protective-equipotential-bonding

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

– means for protective-equipotential-bonding in equipment, see clause 7;
– earthed or unearthed protective-equipotential-bonding in the installation (see note);
– protective conductor (PE);
– PEN conductor;
– protective screening;
– earthed point of the source or artificial neutral point;
– earth electrode (including earth electrodes for potential grading)
– earthing conductor.

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

– main equipotential bonding connecting together
  - main protective conductor;
  - main earthing conductor or main earthing terminal;
  - metallic pipes supplying services within the building, e.g. gas, water;
  - structural metallic parts, central heating and air-conditioning systems, if applicable;
  - any metallic sheath of cables (for telecommunication cables, if permitted by the owners or operators of these cables)
– supplementary equipotential bonding connecting accessible conductive parts together
– local equipotential bonding connecting accessible conductive parts together in a local area where specific conditions exist.

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

**5.2.2.1** 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.

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**5.2.2.2** The protective-equipotential-bonding system shall be of sufficiently low impedance to avoid hazardous potential difference between parts in case of an insulation failure and, if necessary, be used in association with a protective device operated by the fault current (see 5.2.4). The maximum difference in potential and its duration shall be based on IEC 60479-1.

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

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

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

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

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

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

**5.2.2.5** 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 5.2.2.2, 5.2.2.3 and 5.2.2.4 is maintained.

**5.2.2.6** 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 disconnected first.

**5.2.2.7** With the exception described in 5.2.2.8, no element of the protective-equipotential-bonding shall contain any device which might reasonably be expected to break the electrical continuity or introduce significant impedance.

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

**5.2.2.8** Where elements of the protective-equipotential-bonding can be interrupted by the same coupler or plug-and-socket-outlet device as the relevant supply conductors, the protective-equipotential-bonding 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 when interruption and reconnection are only possible with the equipment in de-energized condition.

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

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

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### 5.2.3 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 5.2.2, and

– shall itself comply with the requirements for elements of protective-equipotential-bonding system, see 5.2.2.2, 5.2.2.3 and 5.2.2.4.

### 5.2.4 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 5.2.5). The permissible value of the touch voltage depending on the fault duration shall be specified by technical committees based on IEC 60479-1.

### 5.2.5 Automatic disconnection of supply

For automatic disconnection of supply

– a protective-equipotential-bonding system shall be provided, and

– a protective device operated by the fault current shall disconnect one or more of the line conductors supplying the equipment, system or installation, in case of a failure of basic insulation.

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

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

**5.2.5.2** The protective device may be provided in any suitable part of the installation, system or equipment, and shall be selected taking into account the characteristics of the fault current loop.

### 5.2.6 Simple separation (between circuits)

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

If any component is connected between the separated circuits, that component shall withstand the electric stresses specified for the insulation which it bridges and its impedance shall limit the prospective current flow through the component to the steady-state touch current values indicated in 5.1.6.

### 5.2.7 Non-conducting environment

The environment shall have an impedance to earth of at least

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

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

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

NOTE 2 Impedance values for higher voltages are under consideration.

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### 5.2.8 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 distance of 1 m in front of the equipment or any conductive part , at a depth of 0,5 m below ground level and are connected to the earthing arrangement.

### 5.2.9 Other provisions

Any other provision for fault protection shall comply with the fundamental rule (see clause 4).

## 5.3 Enhanced protective provisions

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

Subclauses 5.3.1 to 5.3.5 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.

### 5.3.1 Reinforced insulation

Reinforced insulation shall be so designed as to be able to withstand electric, thermal, mechanical and environmental stresses with the same reliability of protection as provided by double insulation (basic insulation and supplementary insulation, see 3.10.1 and 3.10.2, respectively).

NOTE 1 This requires design and test parameters more severe than those specified for basic insulation.

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

NOTE 3 Reinforced insulation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

### 5.3.2 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(5.3.1) rated for the highest voltage present, or
– protective screening (5.2.3) with the protective screen being separated from each adjacent circuit by basic insulation rated for the adjacent circuit voltage (see also 6.6, last paragraph), or
– a combination of these provisions.

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

If any component is connected between the separated circuits, that component shall comply with the requirements for protective impedance devices, see 5.3.4.

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

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### 5.3.3 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 5.1.6.

The requirements of 5.1.6 apply also to any likely failure[3] of a single component of the limited-current-source.

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

### 5.3.4 Protective impedance device

A protective impedance device shall reliably limit the touch current to the values indicated in 5.1.6.

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

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

### 5.3.5 Other provisions

Any other enhanced protective provision for both basic protection and fault protection shall comply with the fundamental rule (see clause 4).

## 6 Protective measures

This clause gives descriptions of the structure of typical protective measures, indicating in some cases which protective provision(s) are for basic protection and which are for fault protection.

More than one of the following protective measures may be used within the same installation, system or equipment.

### 6.1 Protection by automatic disconnection of supply

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 automatic disconnection of supply.

NOTE Automatic disconnection of supply requires, according to 5.2.5, a protective-equipotential-bonding system specified in 5.2.2.

### 6.2 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

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

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

### 6.3 Protection by 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.

### 6.4 Protection by electrical separation

Protective measure in which

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

– fault protection is provided

  • by simple-separation of the separated circuit from other circuits and earth, and

  • by an earth-free protective-equipotential-bonding interconnecting exposed-conductive-parts of the separated circuit where more than one item of equipment is connected to the separated circuit.

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

NOTE 1 Electrical separation is mainly used in low-voltage installations and equipment but the application is not excluded in high-voltage installations and equipment.

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

### 6.5 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.

### 6.6 Protection by SELV

Protective measure in which protection is provided by

– limitation of voltage in a circuit (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 earth conductor is not permitted.

In special locations where SELV is required and where protective screening according to 5.3.2 is applied, the protective screen shall be separated from each adjacent circuit by basic insulation intended for the highest voltage present.

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