

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Measuring relays and protection equipment –
Part 27: Product safety requirements**

**Relais de mesure et dispositifs de protection –
Partie 27: Exigences de sécurité des produits**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEASURING RELAYS AND PROTECTION EQUIPMENT –**Part 27: Product safety requirements**

FOREWORD

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IEC 60255-27 has been prepared by IEC technical committee 95: Measuring relays and protection equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2013. This edition constitutes a technical revision.

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

- a) conflicting statements removed;
- b) scope clarified and statement added that all clauses of the standard are required not just type tests;
- c) terminology, definitions and documentation requirements aligned with IEC 60255-1;
- d) alignment with IEC 61010-1, e.g. HLV definitions;
- e) ingress protection clarified;
- f) dielectric and impulse tests added to mechanical and environmental test requirements;

- g) insulation resistance requirements updated for alignment with other product safety standards;
- h) sample testing removed;
- i) short time limiting thermal overload added;
- j) resistance to mechanical stress added;
- k) low-power voltage and current transformer ports added;
- l) Annex C tables updated to align with base standards;
- m) Annex D voltage dependent resistors and radio transmitters added;
- n) Annex G for risk assessment added.

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

Draft	Report on voting
95/516/FDIS	95/526/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60255 series, published under the general title *Measuring relays and protection equipment*, can be found on the IEC website.

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

- reconfirmed,
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- amended.

INTRODUCTION

This document specifies the safety requirements that are generally applicable to all equipment within its scope. These requirements may be supplemented by general product safety standards and IEC 60664-1.

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 27: Product safety requirements

1 Scope

This part of IEC 60255 specifies the product safety requirements for measuring relays and protection equipment having a rated AC voltage up to 1 000 V, or a rated DC voltage up to 1 500 V. Above these limits, IEC 60664-1 is applicable for the determination of clearance, creepage distance and withstand test voltage.

This document specifies essential safety requirements to minimize the risk of fire and hazards caused by electric shock or injury to the user and property. This document specifies only product safety requirements; functional performance of the equipment is not covered.

This document covers all the ways in which the equipment can be mounted and used in cabinets, racks and panels. This document also applies to auxiliary devices such as shunts, series resistors, transformers, auxiliary control panels, display devices, etc., that are used in conjunction with measuring relays and protection equipment and are tested together.

It is possible that ancillary equipment such as network switches used in conjunction with measuring relays and protection equipment needs to comply with additional safety requirements.

This document does not specify the implementation of individual equipment, circuits and components.

This document applies to equipment designed to be safe at least under the following environmental conditions:

- indoor use;
- altitude up to 2 000 m, in accordance with IEC 60255-1;
- rated ambient temperature range, in accordance with IEC 60255-1;
- maximum external relative humidity, in accordance with IEC 60255-1;
- operating range of auxiliary energizing voltage in accordance with IEC 60255-1;
- applicable overvoltage category;
- applicable pollution degree of the intended environment (pollution degree 2 in most cases).

2 Normative references

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

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

IEC 60127-1, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links*

IEC 60255-1, *Measuring relays and protection equipment – Part 1: Common requirements*

IEC 60255-26, *Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements*

IEC 60352-1, *Solderless connections – Part 1: Wrapped connections – General requirements, test methods and practical guidance*

IEC 60352-2, *Solderless connections – Part 2: Crimped connections – General requirements, test methods and practical guidance*

IEC 60417, *Graphical symbols for use on equipment*. Available at: <http://www.graphical-symbols.info/equipment>

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

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC TS 60695-2-20, *Fire hazard testing – Part 2-20: Glowing/hot-wire based test methods – Hot-wire coil test method – Apparatus, test method and guidance*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

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

IEC 61010-1:2010/AMD1:2016

IEC 61032, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61051-2:2021, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

IEC 61180, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61869-6, *Instrument transformers – Part 6: Additional general requirements for low-power instrument transformers*

IEC 61869-10, *Instrument transformers – Part 10: Additional requirements for low-power passive current transformers*

IEC 61869-11, *Instrument transformers – Part 11: Additional requirements for low-power passive voltage transformers*

IEC 62151, *Safety of equipment electrically connected to a telecommunication network*

3 Terms and definitions

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

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

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

3.1

accessible conductive part

conductive part of electrical equipment touchable under normal use

3.2

accessible part

part which can be touched under normal use with a standard rigid or jointed test finger as specified in 6.2 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016

Note 1 to entry: Circuits intended to be connected to an external accessible circuit are considered as accessible conductive parts, for example wired network ports.

3.3

adjacent circuit

independent circuit

electric circuit which is separated from the considered circuit by applicable insulation

3.4

ambient temperature

ambient air temperature

temperature, determined under prescribed conditions, of the air surrounding the complete equipment

Note 1 to entry: For equipment installed inside an enclosure, it is the temperature of the air outside the enclosure.

Note 2 to entry: The ambient temperature is measured at half the distance from any neighbouring equipment, but not more than 300 mm distance from the equipment case, at middle height of the equipment, protected from direct heat radiation from the equipment.

[SOURCE: IEC 60050-441:1984, 441-11-13, modified – The preferred term "ambient temperature" has been added. In the definition and Note 1 to entry, "switching device or fuse" has been replaced by "equipment". Note 2 to entry has been added.]

3.5

barrier

electrically protective barrier

part providing protection against direct contact from any usual direction of access that is firmly secured in place in such a way that it can only be removed by the use of a tool

[SOURCE: IEC 60050-826:2004, 826-12-23, modified – The preferred term "barrier" has been added. At the end of the definition, "that is firmly secured in place in such a way that it can only be removed by the use of a tool" has been added.]

3.6

basic insulation

insulation of hazardous-live-parts to provide basic protection

[SOURCE: IEC 60050-826:2004, 826-12-14, modified – In the definition, "which provides" has been replaced by "to provide" and the Note has been removed.]

3.7**basic protection**

protection against electric shock under normal conditions

[SOURCE: IEC 60050-195:2021, 195-06-01]

3.8**bounding surface**

outer surface of the equipment case

3.9**cabinet**

free-standing and self-supporting enclosure for housing electrical and/or electronic equipment

Note 1 to entry: A cabinet is usually fitted with doors and/or side panels, which may or may not be removable.

[SOURCE: IEC 60050-581:2008, 581-25-02]

3.10**clearance**

shortest distance, measured in air, between two conductive parts, or between a conductive part and the outer bounding surface of the equipment, whether conductive or not

3.11**comparative tracking index****CTI**

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

[SOURCE: IEC 60050-212:2010, 212-11-59]

3.12**creepage distance**

shortest distance along the surface of a solid insulating material between two conductive parts, or between a conductive part and the bounding surface (accessible part) of the equipment, measured along the surface of insulation

[SOURCE: IEC 60050-151:2001, 151-15-50, modified – The phrase ", or between a conductive part and the bounding surface (accessible part) of the equipment, measured along the surface of insulation" has been added.]

3.13**direct contact**

electric contact of persons with live parts

[SOURCE: IEC 60050-826:2004, 826-12-03, modified – In the definition, the words "or animals" have been omitted.]

3.14**double insulation**

insulation comprising both basic insulation and supplementary insulation

Note 1 to entry: Basic and supplementary insulation are separate, each designed for basic protection against electric shock.

[SOURCE: IEC 60050-195:2021, 195-06-08, modified – The note to entry has been added.]

3.15

enclosure

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

Note 1 to entry: Enclosures can provide protection against the spread of fire (see Clause 7).

[SOURCE: IEC 60050-151:2001, 151-13-08, modified – Note 1 to entry has been added.]

3.16

extra low voltage

ELV

voltage not exceeding the maximum value of the prospective touch voltage that is acceptable to be maintained indefinitely under specified conditions of external influences

Note 1 to entry: For the purposes of this document, the ELV values are specified in 4.3.3.2.

SEE: Table A.1

[SOURCE: IEC 60050-195:2021, 195-05-24, modified – The note to entry has been added.]

3.17

fire enclosure

enclosure intended as a safeguard against the spread of fire from within the enclosure to outside the enclosure

[SOURCE: IEC 60050-903:2014, 903-04-10, modified – In the definition, the word "protection" has been replaced by "as safeguard", and Note 1 to entry has been deleted.]

3.18

functional earthed circuit

functional grounded circuit, US

circuit that can include PCB tracks, wiring, components and equipotential bonds that is connected to earth for purposes other than electrical safety

Note 1 to entry: Purposes other than electrical safety include screening and reference point for measurements.

3.19

functional insulation

insulation between conductive parts, necessary for the proper functioning of the equipment

[SOURCE: IEC 60050-195:2021, 195-02-41]

3.20

hazardous energy level

available power level of 240 VA or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 V or more

3.21

hazardous-live-part

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

[SOURCE: IEC 60050-826:2004, 826-12-13]

3.22

hazardous live voltage

HLV

normal use voltage which exceeds ELV levels

Note 1 to entry: For the purposes of this document the ELV values are specified in 4.3.3.2.

3.23**high-integrity part****high-integrity component**

part or component whose specification or qualification is well in excess of the application such that the risk of failure is minimal

3.24**live part**

conductive part intended to be energized under normal operating conditions, including the neutral conductor

[SOURCE: IEC 60050-195:2021, 195-02-19, modified – The last part of the definition " and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor" has been omitted.]

3.25**low-power instrument transformer****LPIT**

arrangement, consisting of one or more current or voltage transformer(s) which may be connected to transmitting systems and secondary converters, all intended to transmit a low-power analogue or digital output signal to measuring instruments, meters and protective or control devices or similar apparatus

EXAMPLE An arrangement consisting of three current sensors, three voltage sensors connected to one merging unit delivering one digital output is considered an LPIT.

Note 1 to entry: LPITs are commonly called non-conventional instrument transformers (NCIT).

Note 2 to entry: The output power produced by these devices is typically lower than or equal to 1 VA.

[SOURCE: IEC 61869-6:2016, 3.1.601]

3.26**low-power current transformer****LPCT**

low-power instrument transformer for current measurement

[SOURCE: IEC 61869-6:2016, 3.1.602]

3.27**low-power voltage transformer****LPVT**

low-power instrument transformer for voltage measurement

[SOURCE: IEC 61869-6:2016, 3.1.603]

3.28**maintenance use**

state of the equipment when being serviced by trained personnel with any tool removable covers and protective measures removed

3.29**non-primary circuit**

circuit electrically isolated from the AC or DC supply and from external voltage transformers and current transformers

3.30

normal use

state of the equipment when installed and operated for its intended purpose, with any tool removable covers and protective measures in place

3.31

overheating

operating at a level such that the thermal limit is exceeded

3.32

overvoltage category

numeral defining a transient overvoltage condition

Note 1 to entry: Overvoltage categories I, II, III and IV are used, see IEC 60664-1.

[SOURCE: IEC 60050-426:2020, 426-04-48]

3.33

protective class I equipment

equipment with basic insulation and protective bonding for protection against electric shock, such that conductive parts on the outside of the equipment case cannot become live (in the event of a failure of the basic insulation)

3.34

protective class II equipment

equipment with

- basic insulation as provision for basic protection against electric shock, and supplementary insulation as provision for fault protection; or
- double- or reinforced-insulation basic and fault protection

Note 1 to entry: There should be no provision for a protective conductor or reliance upon installation conditions for safety purposes. It is, however, possible to connect an earth conductor to protective Class II equipment for functional (for example, EMC) purposes.

3.35

protective class III equipment

equipment, or parts of equipment, in which protection against electric shock relies upon supply from SELV or PELV circuits and in which hazardous voltages are not generated

3.36

pollution

addition of foreign matter, solid, liquid or gaseous that can produce a reduction of dielectric strength or surface resistivity of the insulation

[SOURCE: IEC 60050-442:1998, 442-01-28, modified – In the definition, the word "permanent" has been deleted, and the note has been omitted.]

3.37

pollution degree

number characterizing the expected pollution of the ambient conditions which immediately surround the clearance and creepage distance under consideration as detailed in IEC 60664-1

3.38

primary circuit

circuit electrically connected to the AC or DC supply input and external voltage transformers and current transformers

3.39**protective bonding**

electrical connection of accessible conductive parts or of protective screening to provide electrical continuity by means of connection to an external protective conductor which is securely returned to earth

3.40**protective bonding resistance**

resistance between the protective conductor terminal and a conductive part required to be connected to the protective conductor

3.41**protective conductor**

conductor provided for purposes of electrical safety

[SOURCE: IEC 60050-195:2021 195-02-09]

3.42**protective earthing****protective grounding, US**

earthing for purposes of protection against electric shock

[SOURCE: IEC 60050-195:2021, 195-01-11, modified – The term "electrical safety" has been replaced by "protection against electric shock".]

3.43**protective equipotential bonding circuit****PEB circuit**

circuit with a low impedance path from exposed-conductive-parts to extraneous-conductive-parts, to ensure equal potential throughout thus preventing a hazardous potential difference occurring between such parts in the event of a fault

Note 1 to entry: See Table A.1.

3.44**protective extra low voltage circuit****PELV circuit**

circuit 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: See Table A.1.

3.45**protective impedance**

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

[SOURCE: IEC 60050-442:1998, 442-04-24, modified – In the definition, the term "exposed" has been replaced by "accessible", "in normal use" has been replaced by "under normal use", "electronic switch" has been replaced by "equipment".]

3.46**protective screening****protective shielding, US**

separation of electric circuits and/or conductors from hazardous-live-parts by an electrically protective screen connected to the protective earth

[SOURCE: IEC 60050-195:2021, 195-06-18, modified – In the definition, the words "equipotential bonding system and intended to provide protection against electric shock" have been replaced by "earth".]

3.47

protective separation

separation of one electric circuit from another by means of basic protection and fault protection

[SOURCE: IEC 60050-195:2021, 195-06-19]

3.48

rated impulse voltage

impulse voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages and to which clearances are referred

3.49

rated insulation voltage

RIV

voltage value assigned by the manufacturer to the equipment, or to a part of it, characterizing the specified (long-term) withstand capability of its insulation and to which dielectric voltage tests and creepage distances are referred

Note 1 to entry: The rated insulation voltage is not necessarily equal to the rated voltage of equipment which is primarily related to functional performance.

3.50

rated voltage

value of voltage assigned by the manufacturer, over the normal operating condition of a component, device or equipment

Note 1 to entry: Equipment may have more than one rated voltage value or may have a rated voltage range.

[SOURCE: IEC 60050-442:2014, 442-09-10, modified – In the definition, the term "rated value" has been replaced by "value", the term "to" has been replaced by "over the normal operating condition of", and at the end of the definition the words "and to which operation and performance characteristics are referred" and Note 2 to entry have been omitted.]

3.51

reinforced insulation

insulation that provides a degree of protection against electric shock equivalent to double insulation

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

[SOURCE: IEC 60050-195:2021, 195-06-09]

3.52

restricted access area

area accessible only to users with the proper authorization and knowledge of any safety hazards

[SOURCE: IEC 60050-195:2021, 195-04-04, modified – In the definition, the words "electrically skilled persons and electrically instructed persons" have been replaced by "users" and the words "and knowledge of any safety hazards" have been added.]

3.53

routine test

conformity test made on each individual equipment during or after manufacture

Note 1 to entry: Individual equipment includes complete products and spare parts.

[SOURCE: IEC 60050-151:2001, 151-16-17, modified – In the definition, the word "item" has been replaced by the word "equipment", and Note 1 to entry has been added.]

3.54

safety critical component

component which is relied upon for the integrity of its electrical insulation, mechanical strength, thermal, or flame-retardant properties during normal operation and single fault conditions, to prevent a safety hazard

3.55

safety extra low voltage circuit

separated extra low voltage circuit

SELV circuit

circuit 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)

3.56

screen

shield, US

conductive part that encloses or separates electric circuits and/or conductors

Note 1 to entry: See Table A.1.

3.57

single fault condition

condition in which there is a fault of a single protection (but not a reinforced protection) or of a single component or a device

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.

[SOURCE: IEC 60050-903:2013, 903-01-15]

3.58

solid insulation

material that provides electrical insulation between two opposite surfaces, not along an outer surface

3.59

supplementary insulation

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation

[SOURCE: IEC 60050-195:2021, 195-06-07, modified – ", that provides fault protection" has been replaced by "in order to provide protection against electric shock in the event of a failure of basic insulation".]

3.60

tracking

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

Note 1 to entry: Tracking usually occurs due to surface contamination.

[SOURCE: IEC 60050-212:2010, 212-11-56]

3.61

type test

test of one or more devices made to a given design, to check if these devices comply with the requirements of the standard concerned

[SOURCE: IEC 60050-851:2008, 851-12-05]

3.62

user

person with the appropriate training and experience necessary to be aware of hazards to which they are exposed when accessing the equipment in a restricted access area and aware of measures to minimize a hazardous situation to themselves and other persons

3.63

wired network port

port for the connection of voice, data and signalling transfers intended to interconnect widely dispersed systems by direct connection to a single-user or multi-user communication network

Note 1 to entry: Examples of these include CATV, PSTN, ISDN, xDSL, LAN and similar networks.

Note 2 to entry: These ports may support screened or unscreened cables and may also carry AC or DC power (e.g. PoE) where this is an integral part of the telecommunication specification.

Note 3 to entry: A port generally intended for interconnection of components of a system under test (e.g. EIA-232, IEEE Standard 1284 (parallel printer), Universal Serial Bus (USB), IEEE Standard 1394 ("Fire Wire"), etc.) and used in accordance with its functional specifications (e.g. for the maximum length of cable connected to it), is not considered to be a wired network port.

Note 4 to entry: Optical fibre interfaces are considered as a wired network port. To achieve maximum power dissipation, it is important that the optical fibre ports are active when required during the safety assessment (during temperature rise testing, etc.)

3.64

withstand

ability of the equipment not to be damaged when imposed environmental or test conditions are applied (for example, impulse voltage)

3.65

working voltage

highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

Note 2 to entry: Both open-circuit conditions and normal operating conditions are taken into account.

[SOURCE: IEC 60050-581:2008, 581-21-19, modified – Notes 1 and 2 to entry have been added.]

4 Protection against electric shock

4.1 Protection from contact with hazardous-live-parts

4.1.1 General

Protection against direct contact with hazardous-live-parts shall be provided by adequate insulation, the equipment case or a barrier. Access to the equipment during installation, maintenance use, normal use and decommissioning shall be restricted to users aware of working procedures necessary to ensure safety.

The testing of components and equipment with regard to protection against electric shock shall be conducted as type tests and routine tests as defined in Clause 9.

Unearthed accessible conductive parts which can become hazardous live under a single fault condition shall meet the requirements of 4.1 to 4.10.

4.1.2 Insulation

Any conductive part that is not separated from the hazardous-live-parts by at least basic insulation shall be considered a live part. The insulation requirements shall be determined after consideration of the following influencing factors:

- rated insulation voltage of the circuit under consideration (see C.1.3);
- overvoltage category (see Annex B and Annex C);
- pollution degree (see Annex C);
- isolation class, for example, ELV, SELV, PELV, or PEB (see Annex A).

4.1.3 Equipment enclosure and barriers

The enclosure protection required by the product depends upon face and access level; minimum equipment enclosure requirements are detailed in Table 1.

Table 1 – Equipment enclosure requirements for protection against electric shock

Face	IP Code (IEC 60529:1989, IEC 60529:1989/AMD1:1999, IEC 60529:1989/AMD2:2013)	Requirements
Front panel, sides	IP2X or IPXXB	Hazardous-live-parts shall be located within the equipment enclosure or behind barriers such that they are not accessible under normal use. If a cover can be removed without the use of a tool, warning symbol 12 from Table 12 shall be visible.
Front panel connection(s)	IP2X	The front panel connections and terminal wiring, which are ELV, shall be accessible under normal use.
Top	IP4X	The top surfaces of barriers that are accessible in normal use shall provide ingress protection against falling objects, loose wires, washers, etc. Any such barriers shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection.
Bottom	IP4X	The bottom surfaces of barriers that are accessible in normal use shall provide ingress protection against loose wires, etc. Any such barriers shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection.
Rear	IP2X	Hazardous-live-parts shall be located within the equipment enclosure or behind barriers such that they are not accessible under normal use.
Rear panel connection(s)	IP1X	The rear connection panel, terminal wiring, under normal use shall be in a restricted access area and shall be IP1X or greater.
Corners	-	The corner shall have the highest IP taken from the adjacent sides.

Further requirements for accessible parts are detailed in 4.3.2.

Conformity with 4.1.3 is checked by applying the safety ingress requirements of IEC 60529:1989, IEC 60529:1989/AMD1:1999, and IEC 60529:1989/AMD2:2013.

4.1.4 Hazardous live terminations using stranded wire

The end of a stranded wire shall not be consolidated by soft soldering at places where the wire is subject to contact pressure, unless the method of clamping is designed so as to reduce the likelihood of a bad contact due to cold flow of the solder. Spring terminals that compensate for the cold flow are deemed to satisfy this requirement. Preventing the clamping screws from rotating is not considered to be adequate.

Terminals shall be located, guarded or insulated so that, should a strand of a flexible wire escape when the wire is fitted, there is no likelihood of accidental contact between such a strand and:

- accessible conductive parts; or
- unearthed conductive parts separated from accessible conductive parts by supplementary insulation only.

A loose strand of 8 mm length is normally considered for assessing this risk.

If the manufacturer determines that there is a risk, a recommendation shall be given in the documentation and a warning symbol 14 from Table 12 marked on the equipment. The risk can be eliminated, for example, by the use of an insulated crimp terminal or a single-strand wire.

Conformity with 4.1.4 is checked by inspection.

4.2 Protective impedance

A protective impedance shall limit the current or voltage to the levels of 4.3.3.2 in normal use and 4.10.4.1.2 in single fault condition.

Insulation between the terminations of the protective impedance shall meet the requirements of double insulation or reinforced insulation.

A protective impedance shall be one or more of the following:

- a) an appropriate single component which shall be constructed, selected and tested so that safety and reliability for protection against electric shock are assured. In particular, the component shall be:
 - 1) rated for twice the maximum working voltage;
 - 2) if a resistor, rated for twice the power dissipation for the maximum working voltage;
- b) a combination of components, for example, two Y rated capacitors in series, each rated for the total working voltage across the pair. Each capacitor shall have the same rated capacitance value and a withstand voltage rating of at least 2 000 V RMS, 1 min. This provides basic protection against electric shock in the case of a single fault condition.

Conformity with protective impedance can be demonstrated by application of the appropriate voltage test for double or reinforced insulation in Table C.8 to Table C.11 for a test site altitude of up to 2 000 m. For test site altitudes over 2 000 m, the test voltage should be adjusted in accordance with Table C.12.

Components, wires and connections shall be rated in accordance with the requirements for both normal use and appropriate single fault conditions. It is permissible for double insulation or reinforced insulation to be bridged by components meeting the requirement for protective impedance. Conformity of components with 4.2 and any associated basic insulation shall be checked after a single fault condition assessment or test according to 9.6.5.5. Any associated basic insulation shall be checked by assessment, measurement or testing in accordance with Annex C.

4.3 Accessible parts

4.3.1 General

Unless obvious, determination of whether a part is accessible, under normal use, shall be made as specified below and in 4.3.2.

Circuits intended to be connected to an external accessible circuit shall be considered as accessible conductive parts, for example wired network port.

Appropriate test fingers, as specified in 4.3.2.2, shall be applied without force unless a force is specified. Parts are considered to be accessible if they can be touched with a finger or pin, or if the covering does not provide suitable protection when touched under normal use (see below).

Where accessible conductive parts or circuits are separated from other parts by double insulation or reinforced insulation that is bridged by components in accordance with 4.2, the accessible parts or circuits shall comply with current limits in 4.3.3.2 for the normal use and 4.10.4.1.2 for a single fault condition. These requirements shall apply after dielectric voltage testing.

For hazardous-live-parts, a part is considered to be accessible if the test finger or pin reaches a point nearer to the hazardous-live-part than the applicable clearance for basic insulation at the rated impulse voltage determined from IEC 60664-1.

For equipment accepting plug-in modules, parts are considered to be accessible if they can be touched with the jointed test finger (see 4.3.2.2) up to a depth of 180 mm from the opening in the equipment.

Materials which can easily be damaged are not considered to provide suitable insulation (for example, lacquer, enamel, oxides and anodic films). Non-impregnated hygroscopic materials, such as paper, fibres and fibrous material, are also not considered to provide suitable insulation.

A metallic accessible part is considered to be conductive if its surface is bare or is covered by an insulating layer which does not comply with the requirements of basic insulation.

4.3.2 Determination of accessible parts

4.3.2.1 General

If the user is intended to perform any actions in normal use, with or without the aid of a tool (a screwdriver, a coin, a key, etc.), which will increase the accessibility of parts, such actions shall be taken before performing the examinations of 4.3.2.2 to 4.3.2.3. Examples include:

- removing covers;
- adjusting controls;
- replacing consumable material;
- removing parts.

4.3.2.2 General examination

The jointed test finger (see IEC 61032 and IEC 60529:1989) shall be applied in every possible position. Where a part could become accessible by applying a force, the rigid test finger (see 6.2 of IEC 61010-1:2010 and of IEC 61010-1:2010/AMD1:2016) shall be applied with a force of 10 N. The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action. The test shall be applied to all outer surfaces, including the bottom.

4.3.2.3 Openings for pre-set controls

A metal test pin 3 mm in diameter (force applied 10 N) shall be inserted through holes, in the equipment case, intended to give access to pre-set controls which require the use of a screwdriver or other tool. The test pin shall be applied in every possible direction through the hole; additional information can be found in IEC 61010-1. Penetration shall not exceed three times the distance from the equipment case surface to the control shaft or 100 mm, whichever is smaller.

4.3.2.4 ELV rated or live parts accessible when cover removed

If ELV rated or live parts, such as replaceable batteries or electromechanical relay contacts, are accessible when the cover is removed without the aid of a tool, then a warning label is required, visible when the cover is removed. This warning shall comprise symbol 14 and/or symbol 12 in Table 12.

4.3.2.5 Wiring terminals

Wiring terminals which are accessible under normal use, for example terminals on the front of a product, shall meet the requirement of Table 1.

Wiring terminals which are behind a panel, or in a restricted access area, and cannot be touched in normal use shall be deemed non-accessible. However, a protection of at least type IP1X according to 5.1 of IEC 60529:1989 shall be provided to prevent electric shock due to accidental contact.

If the protection is of type IP0X or IP1X, according to 5.1 of IEC 60529:1989, then the warning symbol 12 in Table 12 shall be used in the vicinity of accessible hazardous live wiring terminals.

Conformity with 4.3.1 to 4.3.2.5 shall be demonstrated by test.

4.3.3 Permissible limits for accessible parts

4.3.3.1 General

The voltage, current, charge or energy between an accessible part and reference test earth, or between any two accessible parts on the same piece of equipment (over a surface or through air), shall not exceed the values of 4.3.3.2 in normal use, nor those of 4.10.4.1.2 in single fault condition.

4.3.3.2 Values under normal use

Values under normal use are listed below. Voltages above the levels of a) are deemed to be hazardous live if any of the levels of b) or c) are exceeded at the same time.

a) Voltage levels: 30 V AC RMS or 60 V DC

For equipment rated for use in wet locations (either device or operator or both in wet locations due to rain, condensation, etc.), the voltage levels are 16 V AC RMS or 35 V DC.

b) Current levels under normal use: indicated in Table 2.

Table 2 – Current levels under normal use

Installation location	Figure 3 or Figure 4 of IEC 60990:2016 Measurement circuit to be used	Sinusoidal waveforms	Non-sinusoidal or mixed frequency waveforms	
		mA RMS	mA peak	mA DC
Dry	Figure 4	0,5	0,7	2
Wet	Figure 3 with $R_S = 375 \Omega$ (instead of $1\,500 \Omega$)	0,5	0,7	2
Dry	Figure 3 with $R_B = 75 \Omega$ Relates to possible burns in the frequency range 30 kHz to 500 kHz	70	-----	-----

- c) After switching off the equipment, capacitors shall be discharged within 5 s to a residual charge in Table 3 or to a voltage of 20 V or less. In the case of installed equipment, where the voltage at the plug-and-socket devices can be touched and these devices can be pulled out when live, without the use of tools, the capacitors shall be discharged within 1 s.

With respect to the above two discharge cases, verification shall be by calculation of the energy in the total in-circuit capacitance, or measurement of the voltage, 5 s or 1 s after switching off the equipment.

If the above parameters cannot be complied with, due to design constraints, there shall be an easily observable warning on the equipment that such capacitors should be safely discharged during decommissioning (symbol 14 from Table 12).

Table 3 – Charge or energy of capacitance levels under normal use

Maximum level	For peak or DC voltages
45 μC	Up to 15 kV
350 mJ	$\geq 15 \text{ kV}$
NOTE Figure 3 of IEC 61010-1:2010 shows the maximum acceptable voltage for the capacitance value for both normal use and single fault condition.	

4.4 Earthing and protective bonding requirements

4.4.1 General

Earthing in equipment may be required for reasons of personnel safety or to reduce the effects of electromagnetic interference. Where there is any conflict between these two requirements, personnel safety shall always take precedence. The acceptable arrangement of protective means against electric shock is illustrated in Figure 4 of IEC 61010-1:2010.

4.4.2 Insulation between live parts and accessible conductive parts

Accessible conductive parts shall be bonded to the protective earth conductor terminal if they could become hazardous live in the case of a single fault of the primary protective means specified in 4.1. Alternatively, such accessible parts shall be separated from parts which are hazardous live by a conductive protective screen or barrier bonded to the protective earth conductor terminal. For measuring and protection equipment, indirect bonding is permitted as an alternative to direct bonding.

Unearthed accessible conductive parts such as equipment doors or flaps, handles, etc. need not be bonded to the protective earth conductor if they are separated from all hazardous-live-parts by double insulation or reinforced insulation.

Equipment of protective class I shall have a minimum of basic insulation between the accessible conductive parts bonded to protective earth conductor and live parts, provided that the insulation cannot be reduced to less than basic insulation by any single fault including

mechanical impact, loose wires and terminals, etc. Mechanical retention can be used to ensure maintenance of basic insulation under a single fault condition. Screws or nuts with lock washers are not regarded as liable to become loose, nor are wires which are mechanically secured by more than soldering alone.

Verification shall be made by measurement, where there is any doubt of conformity.

4.4.3 Protective bonding

4.4.3.1 General

Accessible conductive parts shall be bonded to the protective conductor; it is not, however, essential when one of the following applies.

- Unearthed accessible conductive parts are exclusively related to electrical circuits with automatic disconnection of supply, or with current or voltage limiting in case of direct contact according to 4.3, and the voltage does not exceed ELV limits (see Annex A).
- The unearthed accessible conductive parts are of small dimensions, in normal use are not intended to be grasped, have a low probability of contact, and are separated from hazardous-live-parts by at least basic insulation.

Additional information for the acceptable arrangement of protective bonding against electric shock can be found in IEC 61010-1:2010, Figure 4.

4.4.3.2 Bonding of parts connected to the protective conductor

The equipment design shall ensure that any painting or coating of surfaces within the protective earth bonding circuit does not affect the protective bonding resistance of that circuit.

See 9.6.4.5 for protective bonding test requirements.

4.4.3.3 Protection against corrosion

Conductive parts in contact at protective earthing terminals and connections shall be chosen to minimize electro-chemical corrosion between materials in any working, storage or transport environment conditions as specified in the instructions supplied with the equipment.

Corrosion resistance can be achieved by a suitable plating or coating process.

Conformity with 4.4.3.3 is tested by applying the conducted damp-heat, steady state type test (including protective bonding test requirements given in 9.6.4.5).

4.4.3.4 Interruption of protective bonding

Where the protective bonding to a subassembly of equipment is made by a plug-and-socket device when it is live or conducting, the protective bonding shall not be broken before the live conductors. On re-connection, the protective bonding shall re-connect before the live conductors or, at the latest, together with the live conductors.

Conformity is checked by inspection and/or test.

4.5 Functional earthed circuits

If functional earthing of accessible parts is necessary, the following apply.

- It is permitted to connect the functional earthed circuit to a protective conductor terminal or to a protective bonding conductor.
- The functional earthed circuit shall be separated from ELV circuits by at least basic insulation.

- The functional earthed circuit shall be separated from PEB and PELV circuits by at least functional insulation.
- The functional earthed circuit shall be separated from parts at hazardous voltage in the equipment by either:
 - double insulation or reinforced insulation; or
 - a protectively earthed screen or another protectively earthed conductive part, separated from parts at hazardous voltages by at least basic insulation.

Conformity is checked by inspection, measurement and test.

4.6 Protective conductor connection

Equipment with internal protective bonding shall have means of connection for the external protective conductor, preferably near to the terminals for the respective live conductors.

The protective conductor terminal shall be corrosion-resistant. It shall be capable of accommodating cables of at least the same cross-sectional area as the equipment circuit with the highest current or protection element rating which can cause an earth fault.

The means of connection for the protective conductor shall not be used as a part of the mechanical assembly of the equipment.

Conformity is checked by inspection.

4.7 High leakage current

Where equipment has a continuous leakage current of more than 3,5 mA AC RMS or 10 mA DC in normal use, the protective conductor shall be connected as for permanently connected equipment (see Clause E.2); this shall be stated in the equipment documentation.

Any current measurements shall be performed using the measuring circuit in Figure 4 of IEC 60990:2016. The equipment shall be isolated from earth and from the measuring circuit connected between the protective conductor terminal and the protective conductor.

Conformity is checked by measurement.

4.8 Solid insulation

4.8.1 General

Solid insulation shall be designed to resist the mechanical, electrical, thermal, climatic, and other stresses that are to be expected under normal use throughout the life of the equipment.

Solid insulation shall be designed to withstand mechanical vibration or shock which can be expected during transportation, storage and installation. Conformity with the requirements in 4.8.2 shall be checked after the mechanical tests in 9.6.2.1 and 9.6.2.2.

Wire insulation shall be considered as solid insulation.

Thin, easily damageable materials, such as coating with lacquer or oxides and anode coatings, are considered insufficient to satisfy these requirements.

Conformity with 4.8 is checked by inspection, measurement and test.

4.8.2 Requirements

The maximum temperature of the solid insulation, under normal use at maximum ambient temperature, shall be less than the temperature given for the appropriate class in Table 8 or by 6.10.2.

Conformity of solid insulation shall be verified by performing dielectric voltage and impulse withstand type tests, according to the relevant rated working voltage and overvoltage category, determined from the appropriate Table C.2 to Table C.11, and Table C.12. The test method shall be performed according to the method detailed in 9.6.4.2 and 9.6.4.3. The test proves the minimum distance through the insulation, not the creepage distance across the surface of the insulation.

4.9 Clearances and creepage distances

4.9.1 General

Clearance and creepage distances shall be determined from the appropriate Table C.2 to Table C.11, the clearance and creepage distances can be interpolated for voltages above 300 V.

The minimum creepage distance shall not be less than the minimum clearance in air. These clearances and creepage distances are minimum values; manufacturing tolerances shall additionally be taken into account.

Examples for design and measurement of clearances and creepage distances are given in 6.2 of IEC 60664-1:2020.

Inhomogeneous fields generally apply to equipment.

For the functional insulation of pulsating voltage waveforms, the RMS voltage of the waveform shall be calculated and used as the working voltage in the determination of the required clearances and creepage distances. The amplitude of repetitive peak voltages of short duration (defined as being less than 2 % of the waveform cycle duration) should not exceed 175 % of the rated RMS working voltage used to determine the minimum creepage distance.

Where there is any doubt that the required clearance and creepage distances are compliant, measurements shall be made.

If appropriate, type tests and routine testing of clearances shall be carried out to determine conformity with 4.9, in accordance with Clause 9.

4.9.2 Clearances

4.9.2.1 General

Clearances are specified to withstand the maximum transient overvoltage that can be present on the circuit, either as a result of an external event (such as a lightning strike, or a switching transient), or as the result of the operation of the equipment. Clearances shall be determined with reference to Annex A and Annex C. For clearances in primary circuits, Table B.1 should also be referred to.

The clearance distance between any two circuits shall be based on the maximum transient overvoltage originating from either circuit.

In order to maintain product safety, the clearances for equipment at altitudes greater than 2 000 m shall be multiplied by the factor given in Table 4.

Table 4 – Altitude multiplication factor

Altitude metres	Clearance multiplying factor
2 000	1,00
3 000	1,14
4 000	1,29
5 000	1,48

For test site altitudes other than 2 000 m, the corresponding correction factors of the test voltage are given in Table C.12. If necessary, take appropriate measures to limit the transient voltages the equipment is subjected to; for example, use of spark gaps or transient suppressors.

4.9.2.2 Clearances for primary circuits

The clearances in air relating to primary circuits are determined by the rated impulse voltage (refer to C.1.4).

Basic insulation is the minimum requirement between primary circuits and other circuits, (primary or non-primary circuits) including accessible parts and earthed parts. Additional insulation (for example, functional or supplementary insulation) may be required, depending upon the isolation class (see Annex A). The design of functional insulation, such as that across a primary circuit, shall be such that the risk of fire is minimized.

The clearance values are stated in Annex C. For rated voltages and installation categories other than those given in Annex C tables, refer to IEC 60664-1:2020, Annex F.

NOTE The withstand voltages in Table C.2 to Table C.11 are for inhomogeneous fields. In many cases, the clearance in air between two parts of the equipment is between inhomogeneous and homogeneous; hence, clearances can be proven by testing.

4.9.2.3 Clearances for non-primary circuits

Clearances for non-primary circuits shall withstand the maximum transient overvoltage that can be present on the circuit. If transient overvoltages cannot occur, clearances are based on the rated working voltage.

The clearance values are stated in Annex C. For impulse or working voltages other than those given in Annex C tables, refer to Annex A of IEC 60664-1:2020.

4.9.3 Creepage distances

It is assumed that the equipment within the scope of this document is subject to continuous voltage stress over a long period, requiring the design of appropriate creepage distances.

Creepage distances shall be determined with reference to Annex A and Annex C.

Examples for design and measurement of creepage distances are given in 5.2 and 6.2 of IEC 60664-1:2020.

The creepage distance between any two circuits shall be based on the maximum working voltage across this creepage distance (typically sum of the voltages from these circuits).

If pollution degree 3 or 4 causes persistent conductivity, for example, due to carbon or metal dust, the dimensions for creepage distances cannot be specified. Instead, the surface of insulation shall be designed to avoid a continuous path of conductive pollution (for example, by means of ribs or grooves, as determined by 5.2.5 of IEC 60664-1:2020).

Table C.13 indicates additional protection which may be used to reduce the pollution degree within the equipment. If Table C.13 is used to determine reduced creepage distance, it should be ensured that this is not less than the minimum allowed clearance.

Conformity of creepage distances with 4.9.3 shall be verified by measurement in the case of doubt. It cannot be verified by voltage withstand testing.

Interpolation of creepage distances in Annex C tables is permitted, for both primary and non-primary circuits.

4.10 Single fault conditions

4.10.1 Testing in single fault condition

The equipment shall not present a risk of electric shock or fire after a single fault test. It is not required that a single fault condition is applied to double or reinforced insulation. It need not be functional after the test.

The following requirements apply.

- The fault conditions which are liable to result in electric shock or fire hazards, as generally evidenced by examination of the equipment and its circuit diagram, shall be applied.
- Fault tests shall be made except where it can be demonstrated that it is improbable that a hazard will arise from a particular single fault condition.
- The equipment shall be operated under the least favourable combination of reference test conditions.

These conditions include worst-case tolerance of rated voltage and current, worst-case equipment orientation, whether covers or other removable parts are not fitted during normal use, maximum specified external fuse rating.

NOTE Small parts, such as screws and rivets which are not accessible and are isolated from HLV circuits by at least basic insulation, are not taken into consideration.

Subclause 6.10 provides an alternative to testing for protection against spread of fire under a single fault condition but is not applicable to electric shock hazards.

4.10.2 Application of single fault condition

4.10.2.1 General

Single fault conditions shall be applied one at a time and shall be applied in turn in the most convenient order. Multiple simultaneous faults shall not be applied; they can, however, result from the application of a single fault. The application of a single fault can result in the equipment being in a hazardous state and the test personnel should take appropriate precautions such as the use of safety screens.

After the application of a single fault condition, the equipment or relevant part shall meet the requirements of 4.10.4.

Single fault condition assessment shall include the following.

4.10.2.2 Protective impedance

The following requirements apply.

- If protective impedance is formed by a combination of components, each component shall in turn be short-circuited or disconnected.

- If protective impedance is formed by a combination of basic insulation and a voltage- or current-limiting device, both the basic insulation and the voltage- or current-limiting device shall be subjected to single faults, applied one at a time. Basic insulation shall be short-circuited. The voltage- or current-limiting device shall be short-circuited or disconnected, whichever is less favourable.

Parts of a protective impedance which are high-integrity components need not be short-circuited or disconnected.

4.10.2.3 Transformers

Transformer non-primary windings and sections of tapped windings, which are loaded under normal use shall be tested in turn, one at a time, to simulate short circuits in the load. All other windings are loaded or not loaded, whichever load condition is less favourable.

The primary and non-primary windings of the transformer shall have a short circuit applied between them unless separated by reinforced or double insulation. The reinforced or double insulation shall be tested where thermal damage to the insulation can create a risk of electric shock.

Short circuits shall also be made on the load side of any current-limiting impedance or over-current protective device which is connected directly to the winding.

4.10.2.4 Outputs

Outputs shall be short-circuited one at a time.

4.10.2.5 Insulation between circuits and parts

Functional insulation between circuits and parts shall be short-circuited where this could cause overheating of any material creating a risk of fire, unless that material is of flammability class V-1 or better of IEC 60695-11-10.

Basic insulation in primary circuits shall be bridged to check against the spread of fire.

Supplementary, reinforced and double insulation need not be short-circuited. The exception to this is where thermal damage to the insulation can create a risk of electric shock.

4.10.2.6 Primary circuits and hazardous voltage non-primary circuits

Single fault conditions shall be applied by open-circuiting or short-circuiting components in primary circuits and hazardous voltage non-primary circuits, within the equipment, where these can create a risk of electric shock or fire.

4.10.2.7 Overloads

Single fault conditions shall be applied where a circuit or component overload can create a fire or electric shock hazard. This includes connection of the most unfavourable load impedances to terminals and connectors which deliver power or signal outputs from the equipment.

It is permitted to use fusible links, overcurrent protection devices and the like to provide adequate protection.

Where there are multiple ports with the same internal circuitry, the single fault test can be limited to one port only.

4.10.2.8 Intermittently rated resistors

Continuous dissipation in resistors designed for intermittent dissipation shall be considered under the single fault condition assessment.

4.10.2.9 DC inputs

DC inputs shall be assessed for effects of reverse polarity under worst case conditions.

It is permitted to use fusible links, overcurrent protection devices and the like to provide adequate protection.

Where there are multiple ports with the same internal circuitry, the test can be limited to one port only.

4.10.3 Duration of tests

The equipment shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to one hour since a secondary fault arising from a single fault condition will usually manifest itself within that time. If there is an indication that a risk of electric shock, spread of fire or injury to persons can eventually occur, for example if the temperature has not stabilized, the test shall be continued for a maximum period of four hours unless a hazard occurs before then.

4.10.4 Compliance

4.10.4.1 Conformity with requirements for electric shock protection

4.10.4.1.1 General

A dielectric voltage withstand test according to 9.6.4.3 shall be performed before and after a single fault test to demonstrate that the equipment does not present an electric shock hazard following the application of a single fault condition.

PEB, PELV and SELV circuits shall remain safe to touch after the application of a single fault condition.

Following a single fault condition, accessible parts shall not be hazardous live, as defined in 4.10.4.1.2.

4.10.4.1.2 Values in single fault condition

Values in single fault conditions are given below. Voltages above the levels of a) are deemed to be hazardous live if any of the levels of b) or c) are exceeded at the same time.

a) Voltage levels are 50 V AC RMS or 120 V DC

For voltages of short duration, the duration versus voltage levels are those of Figure 2 of IEC 61010-1:2010/AMD1:2016, measured across a 50 kΩ resistor.

For equipment rated for use in wet locations, the voltage levels are 33 V AC RMS or 70 V DC

b) Current levels are as shown in Table 5.

Table 5 – Current levels in single fault condition

Installation location	Figure 3 or Figure 4 of IEC 60990:2016 Measurement circuit to be used	Sinusoidal waveforms mA AC RMS	Non-sinusoidal or mixed frequency waveforms mA AC peak	mA DC
Dry	Figure 4	3,5	5	15
Wet	Figure 3 with $R_S = 375 \Omega$ (instead of $1\,500 \Omega$)	3,5	5	15
Dry	Figure 3 with $R_B = 75 \Omega$ Relates to possible burns in the frequency range 30 kHz to 500 kHz	500	-----	-----

c) The capacitance level is that defined in Figure 3 in IEC 61010-1:2010.

4.10.4.2 Conformity with requirements for temperature protection

Refer to 6.3.1.

4.10.4.3 Conformity with requirements for protection against the spread of fire

Refer to 6.10.3.

4.10.4.4 Conformity with requirements for hazardous gases and chemicals

Refer to 6.3.2.

4.10.4.5 Conformity with requirements for mechanical protection

Conformity with requirements for mechanical protection is checked by inspection to ensure that no parts are expelled from the equipment due to parts exploding or imploding and that no mechanical hazard is caused by the application of a single fault condition.

The means of protection against expelled parts should not be removable without the aid of a tool. If the protection is removable without the use of a tool, symbol 14 from Table 12 shall be used, and an appropriate warning provided in the documentation.

5 Mechanical aspects

5.1 Protection against mechanical hazards

5.1.1 Stability

Under conditions of normal use, equipment shall not become physically unstable to the degree that it could become a hazard to the user.

Conformity of stability is checked by inspection.

5.1.2 Moving parts

Moving parts shall not be able to crush, cut or pierce parts of the body of the user likely to come into contact with them, nor severely pinch the user's skin under normal use and maintenance use. This requirement does not apply to easily touched moving parts which are obviously intended to operate on parts of materials external to the equipment, for example tripping mechanism. Such equipment should be designed to minimize inadvertent touching of such moving parts (for example, by fitting of guards, handles, etc.).

Conformity of moving parts is checked by inspection.

5.1.3 Edges and corners

All easily touched edges, projections, corners, openings, guards, handles and the like of the equipment case should be smooth and rounded so as not to cause injury during normal use.

Conformity of edges and corners is checked by inspection and, if necessary, by application of an object that represents a finger in size, shape and hardness, to check for abrasions and cuts.

NOTE An acceptable procedure that can be used is outlined in UL 1439.

5.2 Mechanical requirements

The equipment shall, when mounted in accordance with the manufacturer's instructions, comply with the mechanical tests in 9.6.2.1 to 9.6.2.4.

Where higher severity levels are required, they shall be agreed between the manufacturer and the user.

5.3 Mechanical security of terminations

Refer to Annex E.

6 Flammability and resistance to fire

6.1 General

This Clause 6 provides methods and procedures to reduce the risk of fire associated with the equipment to a safe level, by one of the following means:

- eliminating or reducing the sources of ignition within the equipment.
- reducing the amount of combustible (or flammable) materials within the equipment;
- containment of a fire within the equipment, should it occur.

6.2 Requirements for protection against the spread of fire

It is possible that equipment or parts of equipment cause excessive temperatures, under normal use or single fault condition, which could lead to a risk of fire within the equipment or to its surroundings.

In order for a risk of fire within the equipment to exist, all three of the following basic elements shall exist.

- 1) The equipment circuits have sufficient power or energy to be an ignition source.
- 2) There is oxygen present (air is about 21 % oxygen).
- 3) There are combustible materials present to support the combustion process.

The use of the methods and procedures within this Clause 6 offers the following benefits:

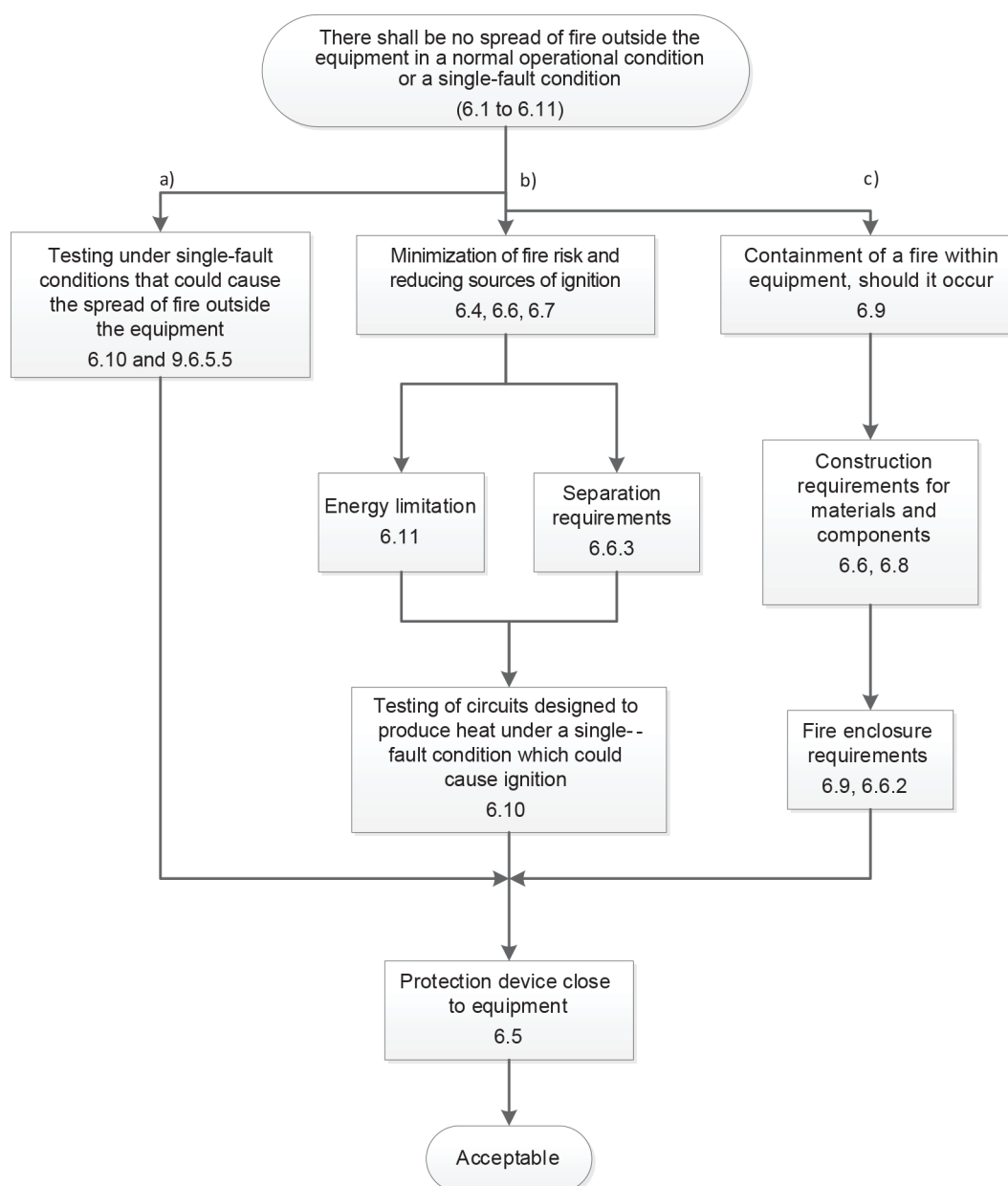
- conformity with fire-protection requirements without tests;
- reduction of single fault condition testing;
- specification of construction methods which allow verification of fire protection by inspection;
- reduction of interpretation differences and testing variables between inspection authorities.

This Clause 6 also details requirements for protection against the spread of fire, maximum temperature limits and limited energy circuits (see 6.11).

There shall be no spread of fire outside the equipment in normal use or in single fault condition. Figure 1 is a flow chart showing methods of conformity verification.

Conformity is checked against the requirements for a protection device (see 6.5) and by at least one of the following methods.

- a) Testing in the single fault conditions (see 6.10 and 9.6.5.5) that could cause the spread of fire outside the equipment. The conformity criteria of 6.10.3 shall be met.
- b) Verifying elimination or reduction of the sources of ignition within the equipment as specified in 6.4.1 and 6.4.2 or 6.4 and 6.11.
- c) Verifying, as specified in 6.9, that if a fire occurs it will be contained within the equipment.



IEC

Figure 1 – Flow chart showing requirements for protection against the spread of fire

6.3 General hazards from overheating and fire

6.3.1 Surface temperature limits for protection against burns

Heating shall not cause a hazard under normal use or single fault conditions, nor shall it cause spread of fire outside the equipment. Table 6 specifies the maximum acceptable temperatures under normal use at maximum ambient temperature. The temperatures in Table 6 can be exceeded under the following conditions.

- For areas unlikely to be touched, with no dimension exceeding 50 mm, 100 °C is allowable.
- Temperatures exceeding the limits, which are for an ambient temperature of 40 °C, are permitted provided that unintentional contact is unlikely and the part has a warning indicating that it is hot, for example, symbol 13 (or 14) of Table 12.

Refer to 4.10 for the maximum acceptable temperatures under a single fault condition.

If easily touched heated surfaces are necessary for functional reasons, they are permitted to exceed the values in Table 6, but shall be recognizable as such by appearance or function or shall be marked. Symbol 13 of Table 12 should be used to indicate that a surface or part is hot.

**Table 6 – Maximum temperature under normal use
and at an ambient temperature of 40 °C**

Accessible parts under normal use	Maximum temperature °C	
	Metal	Non-metallic
Handles, knobs, grips, etc. held or touched for short periods only	60	85
Handles, knobs, grips, etc. continuously held under normal use	55	70
External surfaces of equipment which can be touched	70	80
Parts inside the equipment which can be touched	70	80

Conformity with 6.3.1 is checked by measurement and by inspection of guards and covers, to check that they protect against accidentally touching surfaces that are at temperatures above the values in Table 6. All guards and covers shall be in place when conducting the test. If the guards or covers can be removed without the aid of a tool, symbol 13 or symbol 14 of Table 12 shall be used.

6.3.2 Hazardous gases and chemicals

The equipment shall not liberate hazardous amounts of poisonous or injurious gases under normal operation.

The manufacturer's documentation shall state which potentially poisonous or injurious gases can be liberated, and the quantities.

Conformity is checked by inspection of the manufacturer's documentation. The wide variety of gases makes it impossible to specify conformity tests based on limit values, so reference should be made to tables of occupational threshold limit values.

6.4 Minimization of fire risk

6.4.1 General

The minimization of fire risk, both within the equipment and to cabling and wiring, shall be a major consideration. Protection consistent with reliability and operational requirements shall be provided.

In the event of a single fault condition, any damage shall be contained within the equipment (see 6.10).

Components and materials shall be chosen and used so that there is negligible risk of a fire being caused due to component failure or possible short circuit.

Safety critical components of primary circuits and circuits exceeding ELV voltage limits should comply with relevant component standards; refer to Annex D for information. The equipment and its circuit diagrams shall be examined to determine if single fault condition tests are necessary to demonstrate that there is a negligible risk of fire.

6.4.2 Eliminating or reducing the sources of ignition within the equipment

6.4.2.1 General

The risk of ignition and occurrence of fire is reduced to a tolerable level if one of the following requirements is met for each source of ignition hazard.

6.4.2.2 Limited power

The voltage, current and power available to the circuit or part of equipment are limited as specified in 6.11. Conformity is checked by measurement of limited-energy values as specified in 6.11.

6.4.2.3 Basic insulation

Insulation between parts at different potentials shall meet the requirements for basic insulation, or it shall be demonstrated that short-circuiting the insulation will not cause ignition. Conformity is checked by inspection or by the relevant tests of 9.6.5, applying the criteria of 6.10.

6.4.2.4 Ignition sources

Circuits of the equipment which cannot be classified as limited-energy circuits (see 6.11) are considered ignition sources, in which case conformity is checked by the relevant tests of 9.6.5, applying the criteria of 6.10.

6.5 Cabling and fusing

The manufacturer shall recommend the following to minimize the risk of fire and thermal overload of the AC or DC supply and protective conductors or other equipment fed by the product, taking into account worst-case single fault conditions.

- Connection cables: minimum cross-section and voltage rating.
- Protection devices: fuse or circuit-breaker rating; it should be close to the equipment and should include the protection device characteristic and voltage rating.

NOTE Failures or faults can be due to short circuits within the equipment or to accessible conductive parts, earth faults, short circuit in the output circuits, or control circuit failure. Cabling and fusing is of importance when:

- under use as intended, a fault in the equipment can cause the rated output current of the equipment to be exceeded, resulting in thermal overload of the protective conductor or other equipment fed by the equipment; and
- the equipment fault does not automatically cause a disconnection to its AC or DC supply.

6.6 Flammability of materials and components

6.6.1 General

See Table 14 for the test overview, including flammability.

Conformity is checked by inspection of data on materials, or by performing the flammability tests specified in IEC 60695-11-10 on three samples of the relevant parts (see Table 14 and 9.6.5 of this document). The samples may be any of the following:

- a) complete parts and assemblies of materials as used in product;
- b) sections of a part, including the area with the least wall thickness and any ventilation openings;
- c) samples in accordance with IEC 60695-11-10.

Where safety is involved, components shall meet one of the following:

- the flammability requirements of a relevant IEC component standard which includes such requirements;
- where no relevant IEC standard exists, the flammability requirements of this document;
- applicable flammability requirements of a non-IEC standard where these are at least as high as those of the relevant IEC standard, provided that the component has been approved to the non-IEC standard by a recognized testing authority.

6.6.2 Materials for components and other parts inside fire enclosures

Materials for use within fire enclosures shall comply with any of the following.

- a) Electrical components which do not present a fire hazard under abnormal operating conditions when tested according to 4.10.
- b) Materials and components within an equipment case of volume 0,06 m³ or less, consisting totally of metal and having no ventilation openings, or within a sealed unit containing an inert gas.
- c) One or more layers of thin insulating material, such as adhesive tape, used directly on any surface within the fire enclosure, including the surface of current-carrying parts, provided that the combination of the thin insulating material and the surface of application comply with the requirements of flammability class V-2, or better, of IEC 60695-11-10. Where the thin insulating material is on the inner surface of the fire enclosure itself, the requirements for fire enclosure construction in 6.9 apply.
- d) Electronic components, such as integrated circuit packages, opto-coupler packages, capacitors and other small parts mounted on material of flammability class V-1, or better, of IEC 60695-11-10.
- e) Wiring, cables and connectors insulated with PVC, TFE, PTFE, FEP or neoprene or polyimide or insulated wire that retards flame propagation, as determined by conformity with the recommended performance requirements in the applicable parts of IEC 60332.

NOTE Wire with a flammability RATING of UL 2556 VW-1 or equivalent is considered to meet this requirement.

- f) Individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties used with wiring harnesses.

Conformity with 6.6.1 and 6.6.2 is checked by inspection of the equipment and material data sheets.

6.6.3 Materials for fire enclosures

Materials for components which fill an opening in a fire enclosure, and which are intended to be mounted in that opening shall:

- be of flammability class V-1, or better, of IEC 60695-11-10; or
- pass the flammability test of IEC 60695-11-10; or
- comply with the flammability requirements of the relevant IEC component standard.

NOTE Examples of these components are fuse-holders, switches, connectors and appliance inlets.

Plastic materials of a fire enclosure shall be located more than 13 mm through air from arcing parts such as unenclosed switch contacts.

Plastic materials of a fire enclosure located less than 13 mm through air from non-arcing parts which, under any condition of normal or abnormal operation, could attain a temperature sufficient to ignite the material, shall be capable of passing the test of IEC 60695-2-20. The average time to ignition of the samples shall be not less than 15 s. If a sample melts through without igniting, the time at which this occurs is not considered to be the time to ignition.

Conformity with 6.6.3 is checked by inspection of the equipment and material data sheets and, if necessary, the appropriate flammability test.

6.6.4 Materials for components and other parts outside fire enclosures

Except as otherwise noted below, materials for components and other parts (including mechanical enclosures, electrical enclosures and decorative parts), located outside fire enclosures, shall have a minimum flammability class HB75 according to IEC 60695-11-10 if the thinnest significant thickness of this material is < 3 mm, or flammability class HB40 according to IEC 60695-11-10 if the thinnest significant thickness of this material is ≥ 3 mm, or flammability class HBF. Where a mechanical or an electrical enclosure also serves as a fire enclosure, the requirements for fire enclosures apply (see 6.6.3 and 6.9).

The above flammability requirements do not apply to any of the following:

- a) electrical components which do not present a fire hazard under abnormal operating conditions when tested according to 4.10;
- b) components meeting the flammability requirements of a relevant IEC component standard which includes such requirements;
- c) electronic components, such as integrated circuit packages, opto-coupler packages, capacitors and other small parts that are:
 - 1) mounted on material of flammability class V-1, or better, of IEC 60695-11-10;
 - 2) supplied from a power source of no more than 15 VA, or that complies with limited-energy circuit requirements (see 6.11), under normal operating conditions or after a single fault in the equipment and mounted on material of flammability class HB75 according to IEC 60695-11-10 if the thinnest significant thickness of this material is < 3 mm, or flammability class HB40 according to IEC 60695-11-10 if the thinnest significant thickness of this material is ≥ 3 mm.

Connectors shall comply with one of the following:

- be made of material of flammability class V-1, or better, of IEC 60695-11-10;
- pass the tests of IEC 60695-11-10;
- comply with the flammability requirements of the relevant IEC component standard;
- be located in a secondary circuit supplied by a power source that is limited to a maximum of 15 VA or that complies with limited-energy circuit requirements (see 6.11) under normal operating conditions and after a single fault in the equipment (see 4.10).

Terminal blocks shall comply with the following:

- be made of material of flammability class V-1, or better, of IEC 60695-11-10;
- comply with the temperature limits for the relevant material with maximum load current applied.

6.7 Fire ignition sources

All circuits of equipment which can be classified as including primary circuits or circuits exceeding ELV voltage limits shall be considered to be an ignition source of fire. All electrical components of such circuits are considered likely to be an ignition source of fire.

6.8 Conditions for a fire enclosure

6.8.1 Parts requiring a fire enclosure

The following are considered to have a risk of ignition and therefore require a fire enclosure:

- a) components in primary circuits or exceeding ELV voltage limits. Except where equipment meets the requirements of all the applicable single fault tests of 4.10;
- b) components in non-primary circuits supplied by power sources which exceed the limits specified in 6.11;
- c) components in non-primary circuits supplied by a source complying with limited-energy circuits as specified in 6.11, but not mounted on material of flammability class V-1, or better, of IEC 60695-11-10;
- d) components within a power supply unit or assembly having an output complying with a limited-energy circuit, as specified in 6.11, including overcurrent protective devices, limiting impedances, regulating networks and wiring (see 6.8.2 for exceptions), up to the point where the source output criteria for a limited-energy circuit are met;
- e) components having unenclosed arcing parts, such as open switch and relay contacts in a circuit at hazardous voltage or at a hazardous energy level;
- f) insulated wiring, except as permitted in 6.8.2.

6.8.2 Parts not requiring a fire enclosure

The following do not require a fire enclosure:

- a) motors;
- b) transformers;
- c) electromechanical components complying with 6.6;
- d) components, including connectors, meeting the requirements of 6.6.4, which fill an opening in a fire enclosure;
- e) wiring and cables insulated with PVC, PTFE, TFE, FEP, neoprene or polyimide;
- f) plugs and connectors forming part of a power supply cord or interconnecting cable;
- g) connectors in non-primary circuits supplied by power sources which are limited to a maximum of 15 VA under normal operating conditions and after a single fault in the equipment;
- h) connectors in non-primary circuits supplied by limited-energy circuits complying with 6.11;
- i) other components in non-primary circuits:
 - 1) supplied by a limited-energy circuit complying with 6.11 and mounted on materials of flammability class V-1 or better, of IEC 60695-11-10;
 - 2) supplied by internal or external power sources which are limited to a maximum of 15 VA under normal operating conditions and after a single fault in the equipment and mounted on material having a minimum flammability class HB75 according to IEC 60695-11-10, if the thinnest significant thickness of this material is < 3 mm or flammability class HB40 according to IEC 60695-11-10 if the thinnest significant thickness of this material is ≥ 3 mm;
- j) equipment which has had all the applicable single fault tests of 4.10 applied to both the primary and non-primary circuits;
- k) small parts, such as paper labels, up to 1 500 mm².

If the components become excessively hot under a single fault condition and are mounted within 13 mm of non-metallic materials of V-2 rating or worse, then a hot wire ignition (HWI) test to IEC 60695-2-12 can be carried out on the non-metallic material, of minimum thickness, to determine if there is a risk of fire.

Conformity with 6.8.1 and 6.8.2 is checked by inspection and by evaluation of the data provided by the manufacturer. In the case where no data is provided, conformity is determined by flammability tests.

6.9 Fire enclosures and flame barriers

6.9.1 General

The risk of fire in primary circuits and circuits exceeding ELV limits shall be considered to be reduced to a tolerable level if such circuits of the equipment, and the equipment case, comply with the constructional requirements of 6.9.

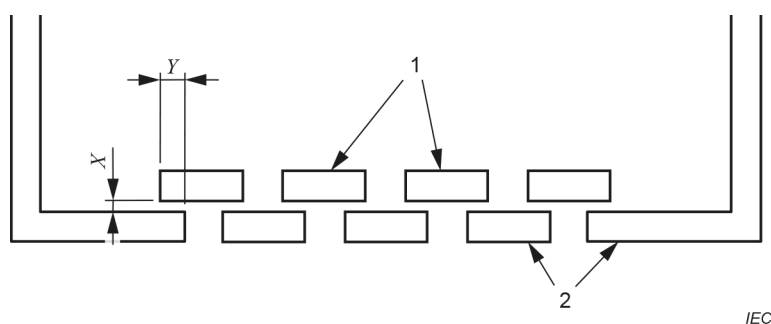
6.9.2 Fire enclosures and flame barrier requirements

The fire enclosure shall meet the following requirements.

- The bottom shall have no openings or, to the extent in Figure 3, shall be constructed with baffles as specified in Figure 2 or be made of metal, perforated as specified in Table 7 or be a metal screen with a mesh not exceeding 2 mm × 2 mm centre to centre and a wire diameter of at least 0,45 mm.
- The equipment case, and any baffle or flame barrier, shall be made of metal (except magnesium) or of non-metallic materials having a flammability class of V-1, or better, of IEC 60695-11-10.
- The equipment case, and any baffle or flame barrier, shall have adequate mechanical strength to protect against electric shock in accordance with Clause 4.

A flame barrier and the bottom of a fire enclosure are considered to comply without test, if in the smallest thickness used, the material is of flammability class V-1 of IEC 60695-11-10 or better.

Conformity with 6.9 is checked by inspection. In case of doubt the flammability class of V-1, or better, is checked on three samples according to IEC 60695-11-10.

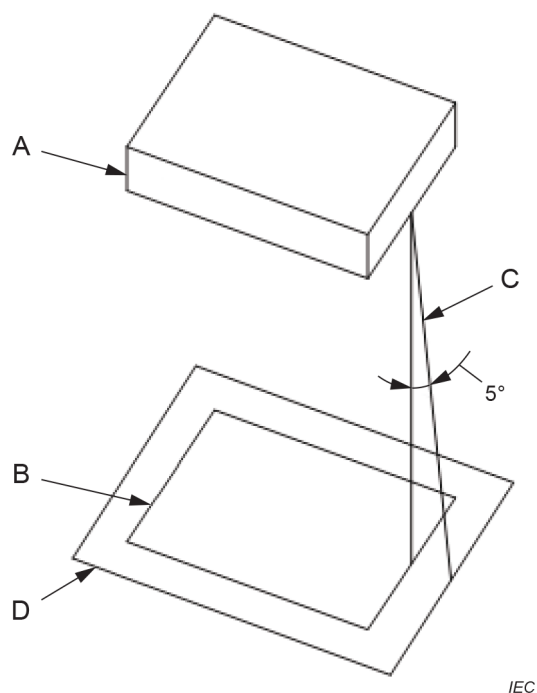


$Y = 2X$ but never less than 25 mm

Key

- 1 Baffle plates (may be below the bottom of the enclosure)
- 2 Bottom of enclosure

Figure 2 – Baffle



Key

- A Part or component of the equipment that is considered to be a source of fire hazard. This consists of an entire component or part of the equipment if it is not otherwise shielded, or the unshielded portion of a component that is partially shielded by its casing.
- B Projection of the outline of A on the horizontal plane.
- C Inclined line that traces out the minimum area of the bottom and sides to be constructed as specified in 6.9. This line projects at a 5° angle from the vertical at every point around the perimeter of A and is oriented so as to trace out the maximum area.
- D Minimum area of the bottom to be constructed as specified in 6.9.

Figure 3 – Location and extent of a flame barrier

Table 7 – Acceptable perforation in the bottom of an equipment case

Minimum thickness	Maximum dimension of holes ^a	Minimum spacing of holes centre to centre
mm	mm	mm
0,76	1,15	1,70
0,76	1,19	2,36
0,81	1,91	3,18
0,89	1,90	3,18
0,91	1,60	2,77
0,91	1,98	3,18
1,00	1,60	2,77
1,00	2,00	3,00

^a The diagonal is the maximum dimension for a square hole.

6.10 Assessment of the fire risk due to a single fault condition

6.10.1 Guidelines for maximum acceptable temperatures when subjecting a circuit or component to a single fault condition

Where it is not practical to protect components against overheating, under a single fault condition, the components shall be mounted on materials of flammability class V-1 or better, of IEC 60695-11-10. Additionally, such components shall be separated from material of a class lower than flammability class V-1 by at least 13 mm of air or by a solid barrier of material of flammability class V-1, or better.

The temperatures specified shall be at the hottest point on the surface of a component or material or within it.

Where it is not possible to meet the above criteria for components and/or circuits subject to overheating under fault conditions, these should be effectively shielded or separated to prevent overheating of their surrounding materials and components (see 6.9). Alternatively, the equipment, mounted under normal use should be subjected to the conformity test in 6.10.3.

6.10.2 Temperature of windings under normal use or a single fault condition

If a hazard could be caused by excessive temperature, the temperature of the insulating material of windings shall not exceed the values of Table 8 in normal use or single fault condition. The values in Table 8 are not applicable for short term overloads. If the temperature of a winding is determined using thermocouples, the values in the table are reduced by 10 °C, except in the case of a winding with embedded thermocouples.

Conformity with 6.10.2 is checked by measurement in the normal use and in the applicable single fault condition.

Table 8 – Insulation material of windings

Class of insulation (as defined in IEC 60085)	Normal use °C	Single fault condition °C
Class A	105	150
Class B	130	175
Class E	120	165
Class F	155	190
Class H	180	210

6.10.3 Conformity of equipment with requirements for protection against the spread of fire

Refer to 9.6.5.5 for single fault testing.

Conformity of equipment to 6.10.3 with requirements for protection against the spread of fire is checked, as a safety type test, by placing the equipment on wrapping tissue (wrapping paper of between 12 g/m² and 30 g/m²), covering a softwood surface and covering the equipment with a single layer of cheesecloth (bleached cotton of approximately 40 g/m²). No molten metal, burning insulation, flaming particles, etc., shall fall on the surface on which the equipment stands, and there shall be no charring, glowing, or flaming of the tissue paper or cheesecloth. Melting of insulation material which is not of importance to the requirements of this document shall be ignored.

6.11 Limited-energy circuit

A limited-energy circuit is a circuit that meets all the following criteria.

- a) The potential appearing in the circuit is not more than 30 V AC RMS or 60 V DC.
- b) The current that can appear in the circuit is limited by one of the following means:
 - 1) the maximum available current is limited inherently or by impedance so that it cannot exceed the relevant value of Table 9;
 - 2) current is limited by an overcurrent protective device according to Table 10;
 - 3) a regulating network limits the maximum available current so that it cannot exceed the relevant value of Table 9 under normal use or as a result of one fault in the regulating network.
- c) It is separated by at least basic insulation from other circuits that would result in energy values exceeding criteria a) and b) above.

If an overcurrent protective device is used, it shall be a fuse or a non-adjustable non-self-resetting electromechanical device.

Conformity to 6.11 is checked by inspection and by measuring the potentials appearing in the circuit, the maximum available current, under the following conditions.

- The potentials appearing in the circuit are measured in the load condition that maximizes the voltage.
- Output current is measured after 60 s of operation, with the resistive load (including short circuit) which produces the highest value of current.

Table 9 – Limits of maximum available current

Open-circuit output voltage, U			Maximum available current A
V			
AC RMS	DC	Peak ^a	
≤ 20	≤ 20	$\leq 28,3$	8
$20 < U \leq 30$	$20 < U \leq 30$	$28,3 < U \leq 42,4$	8
–	$30 < U \leq 60$	–	$150/U$

^a The peak value applies to non-sinusoidal AC and to DC with ripple exceeding 10 %.

Table 10 – Overcurrent protective device

Potential appearing in the circuit, U			Current that the protection device breaks after not more than 120 s ^b
V			
AC RMS	DC	Peak ^a	A
≤ 20	≤ 20	$\leq 28,3$	10
$20 < U \leq 30$	$20 < U \leq 60$	$28,3 < U \leq 42,4$	$200/U$

^a The peak value applies to non-sinusoidal AC and to DC with ripple exceeding 10 %.

^b The evaluation should be based on the specified time-current breaking characteristics of the protection device (which is different from the rated breaking current). (For example, in IEC 60127-1, a 4 A, T-type fuse is specified to break at 8,4 A or less at 120 s.) The breaking current of fuses is dependent on temperature and this should be taken into account if the ambient temperature of a fuse is significantly higher than the room ambient temperature.

7 General and fundamental design requirements for safety

7.1 Climatic conditions for safety

Climatic conditions of equipment denote the conditions in the immediate environment.

The equipment safety shall not be impaired by the environmental ranges declared by the manufacturer. These conditions include:

- temperature, operation and storage;
- humidity, non-condensing;
- atmospheric pressure.

7.2 Electrical connections

The design of electrical terminations and connection points shall be such that the expected reliability will be maintained throughout the life of the equipment. Allowance shall be made for the conditions normally encountered in service, for example, corrosion due to humidity, shocks, heat and creep.

Conformity of protective bonding with 7.2 shall be verified by test.

Wires and cables shall be in accordance with the relevant IEC standards.

Conductors and their cross-sections shall comply with the electrical, mechanical and climatic requirements of this document. Furthermore, the structure of the conductors and their cross-sections shall be matched to the connection method used. For example, connection method without screws or soldering shall be in accordance with IEC 60352-1 or IEC 60352-2.

Current-carrying parts shall have the necessary mechanical strength and current-carrying capacity for their intended use. Current transformer primary windings should be restrained mechanically to ensure circuit continuity is maintained during thermal withstand conditions.

For electrical connections, no contact pressure shall be transmitted through insulating material other than ceramic or other material with characteristics no less suitable, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or yielding of the insulation material.

7.3 Components

7.3.1 General

Refer to Annex D for safety-related guidance on the design and application of components for use in equipment within the scope of this document.

7.3.2 High-integrity part or component

Where short-circuiting or disconnection of a component in a single-fault condition could result in a hazard, high-integrity components shall be used.

High-integrity parts and components are regarded as fault-free in relation to the requirements of this document and are not subject to testing in single-fault conditions.

NOTE In addition to the requirements of this document, high-integrity parts and components are constructed, dimensioned and tested according to IEC publications (where applicable) so that their safety and reliability for the expected application is assured.

A single electronic device which employs electron conduction in a vacuum, gas or semiconductor is not regarded as a high-integrity part.

Conformity with 7.3 is checked by inspection of component manufacturers data or by performing the relevant tests.

7.4 Connection to other equipment

Where equipment is intended to be electrically connected to another product, to an accessory, or to a wired network port, interconnection circuits shall be selected to provide continued performance to the requirements of Table A.1. This is normally achieved by connecting ELV circuits to ELV circuits, SELV circuits to SELV circuits, PELV circuits to PELV circuits, PEB circuits to PEB circuits and TNV circuits to TNV circuits. For definitions and information on TNV circuits, refer to IEC 62151. Interconnecting cables can carry more than one type of circuit (SELV circuit, TNV circuit, ELV circuit, hazardous voltage circuit, etc.) provided that they are separated as required by this document. It is possible that HLV circuits be connected to other HLV circuits of other equipment which have compatible electrical ratings.

Conformity with 7.4 is checked by inspection.

Where additional products are specifically complementary to the host (first) equipment (for example, a separate control interface for the equipment), ELV circuits are permitted as interconnection circuits between these items, provided that these continue to meet the requirements of this document when connected together.

7.5 High-intensity light sources

Equipment using high-intensity light sources – for example, fibre optic interfaces – shall be designed in accordance with IEC 60825-1.

7.6 Explosion

7.6.1 General

For information on components not covered by 7.6, see 7.3 and Annex D.

7.6.2 Components at risk of explosion

7.6.2.1 General

When components liable to explode if overheated or overcharged are not provided with a pressure-release device, protection for the user shall be incorporated in the equipment (see 4.10.4.5).

Pressure-release devices shall be located such that a discharge will not cause a hazard to the user. The construction shall be such that any pressure-release device is not obstructed.

7.6.2.2 Batteries

Batteries shall not cause explosion or produce a fire hazard as a result of excessive charge or discharge or if installed with incorrect polarity. Where necessary, protection shall be incorporated in the equipment, unless the manufacturer's instructions specify that it is for use only with batteries which have built-in protection. See Annex F for examples of battery protection circuits.

If an explosion or fire hazard could occur through fitting a battery of the wrong type (for example, where a battery with built-in protection is specified), there shall be a warning marking (see 8.1.10) on or near the battery compartment or mounting and a warning in the manufacturer's instructions. An acceptable marking is symbol 14 of Table 12 (refer to documentation from the manufacturer).

If the equipment has means for charging rechargeable batteries, and if non-rechargeable cells could be fitted and connected in the battery compartment, there shall be a warning marking in or near the compartment (see 8.1.8 and 8.1.10).

The battery compartment shall be designed so that there is no possibility of explosion or fire caused by build-up of flammable gases. Batteries shall be so mounted that safety cannot be impaired by leakage of their electrolyte.

For batteries intended to be replaced by the user, if an attempt is made to install a battery with its polarity reversed, no hazard shall arise.

Conformity is checked by inspection, including inspection of battery data, to establish that failure of a single component cannot lead to an explosion or fire hazard. If necessary, a short circuit and an open circuit are made on any single component (except the battery itself) whose failure could lead to such a hazard.

8 Marking, documentation and packaging

8.1 Marking

8.1.1 General

When mounted in its normal operating position, the equipment should carry, where possible, markings in accordance with 8.1.2 to 8.1.11 inclusive. These markings shall, where possible, be visible from the exterior of the equipment or be visible by removing a cover or the opening of an aperture without the aid of a tool, if the cover or aperture is intended to be removed by the user.

Where, because of space limitations, it is not possible for these markings to be visible in the normal operating position or they are found elsewhere on the equipment, an explanation of these symbols shall be included in the documentation (see Table 12 for the description of the symbols).

Where a hazard exists, the caution symbol 14 of Table 12 and associated hazard symbol shall be displayed as close as possible to the hazard, for example caution symbol and high voltage symbol placed on terminal block. If general warnings are needed, the caution symbol 14 of Table 12 shall be used and the meaning of this shall be detailed in the documentation.

For rack or panel equipment, markings are permitted to be on any surface that becomes visible after removal of the equipment from the rack or panel.

Markings that apply to the whole equipment shall not be placed on parts that can be removed by the user without the use of a tool.

The values of preferred voltages, currents, frequency and their tolerances should be as specified in IEC 60255-1.

The markings listed in Clause 8 shall be considered to be safety-related.

8.1.2 Identification

The equipment shall, as a minimum, be marked with:

- the name or trademark of the manufacturer or supplier;
- the model or type reference;
- if equipment bearing the same distinctive designation (model number) is manufactured at more than one location, the manufacturing location (factory location can be in code).

If the equipment consists of two parts, the part accessible under normal use shall be marked with type and manufacturer. The other part should have all markings in accordance with 8.1.

Conformity with 8.1 shall be checked by inspection.

8.1.3 Auxiliary supplies, measurands, inputs and outputs

8.1.3.1 General requirements for marking

For marking, the following shall be taken into account:

- AC – with symbol 2 of Table 12 and rated frequency or frequency range;
- DC – with symbol 1 of Table 12;
- symbol 3 of Table 12 on equipment for AC and DC supply;
- symbol 4 of Table 12 on equipment for 3 phase AC supply;
- a hyphen (-) shall be used to separate the lower and upper rated voltages and measurands, for example, 125 V-230 V;
- for selectable voltage or current markings:
 - the lower and upper selectable values shall be separated by means of a solidus, forward slash (/), for example, 125 V/230 V, 1 A/5 A;
 - when equipment uses voltages or frequencies where switching is automatic then the markings shall be according to symbol 15 of Table 12 or the word "AUTO" (see the examples in Table 12);
 - where an operating voltage is achieved using an external, separate device, for example, an additional series resistor, then the equipment shall be marked with this operating voltage followed by the legend +EXT.R. (in capital letters), for example, 125 V+EXT.R;
- the burden in watts (active power) or volt-amperes (apparent power) or the rated input current, with all accessories or plug-in modules connected;
- the documentation shall specify the burden of individual digital inputs, output relays and other I/O ports of significant burden in order for the user to calculate the worst-case burden for the equipment application;
- the values shall be measured with the equipment powered at rated voltage, but without being operational; the measured value shall not exceed the marked value by more than 10 %;
- the rated supply voltage(s) or the rated supply voltage range.

If the equipment can be used on more than one voltage range then the separate voltage ranges shall be marked unless their maximum and minimum values do not differ by more than 20 % of the mean value.

If a user can set different rated supply voltages on the equipment then a means of indication for the set voltage shall be provided on the equipment. If AC or DC supply setting alteration can be achieved without the use of a tool, then the action of changing the setting shall also change the indication.

8.1.3.2 Auxiliary supply

The following information shall be provided:

- on the equipment and in the documentation:
 - AC and/or DC supply;
 - the rated values;
- in the documentation:
 - the burden;
 - the operating voltage range (in accordance with IEC 60255-1).