IEC 61010-2-201

Edition 3.0 2024-10
EXTENDED VERSION

INTERNATIONAL STANDARD

colour inside

This full version of IEC 61010-2-201:2024 includes the content of the references made to IEC 61010-1:2010+AMD1:2016 CSV

Safety requirements for electrical equipment for measurement, control, and laboratory use –
Part 2-201: Particular requirements for control equipment

IEC 61010-2-201:2024-10 EXV(en)

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Safety requirements for electrical equipment for measurement, control, and laboratory use –
Part 2-201: Particular requirements for control equipment

INTERNATIONAL
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SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 1: General requirements

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by IEC technical committee 66: Safety of measuring, control and laboratory equipment.

The text of this interpretation sheet is based on the following documents:

ISH	Report on voting
66/497A/ISH	66/505/RVD

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

IEC 61010-1:2010 contains a requirement in 6.8.3.1 pertaining to voltage testers for type tests as follows:

"The generator shall be able to supply a power of at least 500 VA."

This has given rise to the following questions:

How does one interpret the requirement for voltage testers in 6.8.3.1 of IEC 61010-1:2010? Specifically, this subclause requires that "The generator shall be able to supply a power of at least 500 VA." Does this requirement apply throughout the rated output range of the voltage tester? What is meant by the word "generator"? Is the "generator" the power supply within the voltage tester, or the voltage tester output, or something else?

<u>Interpretation:</u>

"A voltage tester used for type tests must be able to deliver at least 500 VA at its full-rated output voltage. It does not necessarily need to deliver 500 VA if set for lower voltages.

For example, a voltage tester that can deliver 100 mA at any test output voltage up to 5 000 V (and a current corresponding to 500 VA above 5 000 V) would meet the requirement.

The requirements for voltage testers used for routine (production line) tests are included in Annex F. The requirements of 6.8.3.1 do not apply to these voltage testers."

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 2-201: Particular requirements for control equipment

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IEC 61010-2-201:2024 EXV includes the content of IEC 61010-2-201:2024, and the references made to IEC 61010-1:2010+AMD1:2016 CSV.

The specific content of IEC 61010-2-201:2024 is displayed on a blue background.

IEC 61010-2-201 has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2017. This edition constitutes a technical revision.

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

a) 1.1.1: the related equipment included in the Scope has been clarified;
b) 4.3.2.101: the optical fibre module has been deleted;
c) 5.4.3: equipment installation has been clarified;
d) 6.7.1.1: revision of the figure representing insulation between separate circuits has been included;
e) 6.7.101: the subclause relating to insulation for FIELD WIRING TERMINALS of OVERVOLTAGE CATEGORY II with a nominal voltage up to 1 000 V has been deleted;
f) 6.7.1.101: a new subclause relating to insulation for SELV/PELV CIRCUITS has been included;
g) 6.8.3: specification of voltage tester has been added;
h) 6.9.3: an additional exception relating to colour coding has been included;
i) 6.9.101: a new subclause relating to wiring for secondary circuits e.g. SELV/PELV has been included;
j) 8.2.2.101: additional requirements for glass displays have been included;
k) 8.3: the subclause relating to the drop test has been removed;
l) 9.3.2: additional requirements for material of connectors and insulating material have been included;
m) The particular requirements for non-metallic material have been clarified;
n) Clause 11: the particular requirements for protection against HAZARDS from fluid and solid foreign objects have been removed;
o) 12.4: an additional subclause relating to microwave radiation has been included;
p) 14.102: the description of switching devices has been clarified;

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

Draft	Report on voting
65/1049/FDIS	65/1095/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/standardsdev/publications.

A list of all parts in the IEC 61010 series, published under the general title *Safety requirements for electrical equipment for measurement, control, and laboratory use*, can be found on the IEC website.

This document is to be used in conjunction with IEC 61010-1:2010, and IEC 61010-1:2010/AMD1:2016.

This document supplements or modifies the corresponding clauses in IEC 61010-1 so as to convert that publication into the IEC standard: *Particular requirements for control equipment.*

Where a particular subclause of IEC 61010-1 is not mentioned in this document, that subclause applies as far as is reasonable. Where this document states "addition", "modification", "replacement", or "deletion", the relevant requirement, test specification or note in IEC 61010-1 should be adapted accordingly.

In this document,

a) the following print types are used:
   – requirements and definitions: in roman type;
   – NOTES: in smaller roman type;
   – *conformity and tests: in italic type*;
   – terms used throughout this document which have been defined in Clause 3: SMALL ROMAN CAPITALS.

b) subclauses, figures, tables and notes which are additional to those in IEC 61010-1 are numbered starting from 101. Additional annexes are lettered starting from AA and additional list items are lettered from aa).

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,
- withdrawn, or
- revised.

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INTRODUCTION to IEC 61010-1:2010

This International Standard specifies the safety requirements that are generally applicable to all equipment within its scope. For certain types of equipment, these requirements will be supplemented or modified by the special requirements of one, or more than one, particular part 2 of the standard which must be read in conjunction with the part 1 requirements.

INTRODUCTION IEC 61010-2-201:2024

IEC 61010-2-2xx documents are a series of standards on the safety of industrial-process measurement, control and automation equipment.

This document specifies the complete safety related requirements and related tests for control equipment (e.g. programmable controller (PLC), the components of distributed control systems (DCS), I/O devices, human machine interface (HMI)).

Safety terms of general use are defined in IEC 61010-1. More specific terms are defined in each relevant part of the IEC 61010 series.

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 2-201: Particular requirements for control equipment

1 Scope and object

1.1 Scope

1.1.1 Equipment included in scope

This part of IEC 61010 specifies safety requirements and related verification tests for control equipment or their associated peripherals, or both.

Some equipment examples are:

- programmable logic controller (PLC);
- programmable automation controller (PAC);
- distributed control systems (DCS);
- industrial PC (computers) and panel PC;
- programming and debugging tools (PADTs);
- displays and human-machine interfaces (HMI);
- any product performing the function of control equipment or their associated peripherals, or both;
- positioners; and
- control equipment which have as their intended use the command and control of machines, automated manufacturing and industrial processes, for example discrete and continuous control.

Components of the above named equipment and within the scope of this document are, for example:

- (auxiliary) stand-alone power supplies;
- peripherals such as digital and analogue I/O,
- remote-I/O;
- industrial network equipment, embedded or stand-alone (e.g. switches, routers, wireless base station).

Control equipment and their associated peripherals are intended to be used in an industrial environment. This document considers equipment designed as OPEN or ENCLOSED EQUIPMENT.

NOTE 1 Control equipment intended also for use in other environments or for other purposes (example: for use in building installations to control light or other electrical installations, or for use on cars, trains or ships) can have additional conformity requirements defined by the safety standard(s) for these applications. These requirements can involve for example: insulation, spacings and power restrictions.

NOTE 2 Computing devices and similar equipment within the scope of the IEC 60950 series or the IEC 62368 series and conforming to their requirements are considered to be suitable for use with control equipment within the scope of this document. However, some of the requirements of the IEC 60950 series for resistance to moisture and liquids are less stringent, IEC 61010-1:2010, 5.4.4, second paragraph takes this aspect into account.

Control equipment covered in this document is typically intended for use in OVERVOLTAGE CATEGORY II (IEC 60664-1) in low-voltage installations, where the RATED equipment supply voltage does not exceed 1 000 V a.c. RMS (50/60 Hz), or 1 000 V d.c..

Where control equipment is intended for installation to supply systems with OVERVOLTAGE CATEGORY III or IV, additional requirements are identified in Annex K.

The requirements of ISO/IEC Guide 51 and IEC Guide 104, as they relate to this part of IEC 61010, are incorporated herein.

1.1.2 Equipment excluded from scope

This document does not deal with aspects of the overall automated system, for example a complete assembly line. Control equipment (e.g. DCS and PLC), their application programme and their associated peripherals are considered as components (components in this context are items which perform no useful function by themselves) of an overall automated system.

Since control equipment (e.g. DCS and PLC) are component devices, safety considerations for the overall automated system including installation and application are beyond the scope of this document. Refer to the IEC 60364 series or applicable national and local regulations for electrical installation and guidelines.

1.1.3 Computing equipment

This standard applies only to computers, processors, etc. which form part of equipment within the scope of this standard or are designed for use exclusively with the equipment.

NOTE Computing devices and similar equipment within the scope of IEC 60950 and conforming to its requirements are considered to be suitable for use with equipment within the scope of this standard. However, some of the requirements of IEC 60950 for resistance to moisture and liquids are less stringent than those in this standard (see 5.4.4 second paragraph)).

1.2 Object

1.2.1 Aspects included in scope

The purpose of the requirements of this document is to ensure that all HAZARDS to the OPERATOR, SERVICE PERSONNEL and the surrounding area are reduced to a tolerable level.

NOTE By using the terms "OPERATOR" and "SERVICE PERSONNEL" this document considers the perception of HAZARDS depending on training and skills. Annex AA provides a general approach in this regard.

Requirements for protection against particular types of HAZARD are given in Clauses 6 to 13, as follows:

a) electric shock or burn (see Clause 6);
b) mechanical HAZARDS (see Clauses 7 and 8);
c) spread of fire from the equipment (see Clause 9);
d) excessive temperature (see Clause 10);
e) effects of fluids and fluid pressure (see Clause 11);
f) effects of radiation, including lasers sources, and sonic and ultrasonic pressure (see Clause 12);
g) liberated gases, explosion and implosion (see Clause 13).

Requirements for protection against HAZARDS arising from REASONABLY FORESEEABLE MISUSE and ergonomic factors are specified in Clause 16.

RISK assessment for HAZARDS or environments not fully covered above is specified in Clause 17.

NOTE Attention is drawn to the existence of additional requirements regarding the health and safety of labour forces.

1.2.2 Aspects excluded from scope

This document does not cover:

a) reliability, functionality, performance, or other properties of the control equipment not related to safety;

b) mechanical or climatic requirements for operation, transport or storage;

c) EMC requirements (see e.g. the IEC 61326 series or IEC 61131-2);

d) protective measures for explosive atmospheres (see e.g. the IEC 60079 series);

e) functional safety (see e.g. the IEC 61508 series, IEC 61131-6).

1.3 Verification

This standard also specifies methods of verifying that the equipment meets the requirements of this standard, through inspection, TYPE TESTS, ROUTINE TESTS, and RISK assessment.

1.4 Environmental conditions

1.4.1 Normal environmental conditions

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

a) indoor use;

b) altitude up to 2 000 m;

c) temperature 5 °C to 40 °C;

d) maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;

e) MAINS supply voltage fluctuations up to ±10 % of the nominal voltage;

f) TRANSIENT OVERVOLTAGES up to the levels of OVERVOLTAGE CATEGORY II;

NOTE 1 These levels of transient overvoltage are typical for equipment supplied from the building wiring.

g) TEMPORARY OVERVOLTAGES occurring on the MAINS supply.

h) applicable POLLUTION DEGREE of the intended environment (POLLUTION DEGREE 2 in most cases).

NOTE 2 Manufacturers may specify more restricted environmental conditions for operation; nevertheless the equipment must be safe within these normal environmental conditions.

1.4.2 Extended environmental conditions

This standard applies to equipment designed to be safe not only in the environmental conditions specified in 1.4.1, but also in any of the following conditions as RATED by the manufacturer of the equipment:

a) outdoor use;

b) altitude above 2 000 m;

c) ambient temperatures below 5 °C or above 40 °C;

d) relative humidity above the levels specified in 1.4.1;

e) MAINS supply voltage fluctuations exceeding ±10 % of the nominal voltage;

f) WET LOCATION;

g) TRANSIENT OVERVOLTAGES up to the levels of OVERVOLTAGE CATEGORY III or IV (see Annex K).

2 Normative references

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

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

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

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

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

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

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60335-2-24, *Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers.*

IEC 60335-2-89, *Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015

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

IEC 60417, *Graphical symbols for use on equipment*

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

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

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end products (GWEPT)*

IEC 60695-11-3, *Fire hazard testing – Part 11-3: Test flames – 500 W flames – Apparatus and confirmational test methods*

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

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

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

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

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

IEC 60947-2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

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

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – Semiconductor motor controllers, starters and soft-starters*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61010-031, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test*

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 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61180 (all parts), *High-voltage test techniques for low-voltage equipment*

IEC 61180-1, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements*

IEC 61180-2, *High-voltage test techniques for low-voltage equipment – Part 2: Test equipment*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

IEC 61810-1:2015, *Electromechanical elementary relays – Part 1: General and safety requirements*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external impacts (IK code)*

IEC 62471, *Photobiological safety of lamps and lamp systems*

IEC TR 62471-2, *Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety*

IEC 62598, *Nuclear instrumentation – Constructional requirements and classification of radiometric gauges*

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

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

ISO 306:2013, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 361, *Basic ionizing radiation symbol*

ISO 3746, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 7000, *Graphical symbols for use on equipment*

ISO 9614-1, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

ISO 13857, *Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs*

EN 378-2, *Refrigerating systems and heat pumps – Safety and environmental requirements. Design, construction, testing, marking and documentation*

3 Terms and definitions

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

3.1 Equipment and states of equipment

3.1.1
FIXED EQUIPMENT
equipment fastened to a support, or otherwise secured in a specific location

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

3.1.2
PERMANENTLY CONNECTED EQUIPMENT
equipment that is electrically connected to a supply by means of a permanent connection which can be detached only by the use of a TOOL

3.1.3
PORTABLE EQUIPMENT
equipment intended to be carried by hand and not fixed during NORMAL USE

3.1.4
HAND-HELD EQUIPMENT
PORTABLE EQUIPMENT intended to be supported by one hand during NORMAL USE

3.1.5
TOOL
external device, including keys and coins, used to aid a person to perform a mechanical function

3.1.6
DIRECT PLUG-IN EQUIPMENT
equipment with a MAINS plug that is attached to the equipment housing without the use of a MAINS supply cord so that the equipment is supported by the MAINS socket-outlet

3.2 Parts and accessories

3.2.1
TERMINAL
component provided for the connection of a device to external conductors

[IEC 60050-151:2001, 151-12-12, modified]

NOTE TERMINALS can contain one or several contacts and the term therefore includes sockets, connectors, etc.

3.2.2
FUNCTIONAL EARTH TERMINAL
TERMINAL by which electrical connection is made directly to a point of a measuring or control circuit or to a screening part and which is intended to be earthed for any functional purpose other than safety

NOTE For measuring equipment, this TERMINAL is often called the measuring earth TERMINAL.

3.2.3
PROTECTIVE EARTH TERMINAL
TERMINAL which is bonded to conductive parts of equipment for safety purposes and is intended to be connected to an external protective earthing system

Note 1 to entry: PROTECTIVE EARTH TERMINAL is most familiar to industrial users, manufacturers, etc. Therefore since this document is targeted towards industrial use, the most familiar term is utilized.

3.2.4
ENCLOSURE
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-151:2001, 151-13-08]

3.2.5
PROTECTIVE BARRIER
part providing protection against direct contact from any usual direction of access

[IEC 60050-195:1998, 195-06-15]

NOTE Depending on its construction, a PROTECTIVE BARRIER can be called a casing, cover, screen, door, guard, etc.

A PROTECTIVE BARRIER can act alone; it is then only effective when it is in place. A PROTECTIVE BARRIER can also act in conjunction with an interlocking device with or without guard locking; in this case, protection is ensured whatever the position of the PROTECTIVE BARRIER.

3.3 Quantities

3.3.1
RATED (value)
quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

[IEC 60050-151:2001, 151-16-08, modified]

3.3.2
RATING
set of RATED values and operating conditions

[IEC 60050-151:2001, 151-16-11]

3.3.3
WORKING VOLTAGE
highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at RATED voltage

NOTE 1 Transients and voltage fluctuations are not considered to be part of the WORKING VOLTAGE.

NOTE 2 Both open-circuit conditions and normal operating conditions are taken into account.

3.4 Tests

3.4.1
TYPE TEST
test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of this standard

NOTE This is an amplification of the IEC 60050-151:2001, 151-16-16 definition to cover design as well as construction.

3.4.2
ROUTINE TEST
conformity test made on each individual item during or after manufacture

[IEC 60050-151:2001, 151-16-17]

3.5 Safety terms

3.5.1
ACCESSIBLE (of a part)
able to be touched with a standard test finger or test pin, when used as specified in 6.2

3.5.2
HAZARD
potential source of harm

3.5.3
HAZARDOUS LIVE
capable of rendering an electric shock or electric burn

3.5.4
MAINS
low-voltage electricity supply system to which the equipment concerned is designed to be connected for the purpose of powering the equipment

3.5.5
MAINS CIRCUIT
circuit which is intended to be directly connected to the MAINS for the purpose of powering the equipment

3.5.6
PROTECTIVE IMPEDANCE
component or assembly of components whose impedance, construction and reliability are suitable to provide protection against electric shock

3.5.7
PROTECTIVE BONDING
electrical connection of ACCESSIBLE conductive parts or protective screening to provide electrical continuity to the means for connection of an external protective conductor

3.5.8
NORMAL USE
operation, including stand-by, according to the instructions for use or for the obvious intended purpose

3.5.9
NORMAL CONDITION
condition in which all means for protection against HAZARDS are intact

3.5.10
SINGLE FAULT CONDITION
condition in which one means for protection against HAZARD is defective or one fault is present which could cause a HAZARD

NOTE If a SINGLE FAULT CONDITION results unavoidably in one or more other fault conditions, all the failures are considered as one SINGLE FAULT CONDITION [IEC Guide 104].

3.5.11
OPERATOR
person operating equipment for its intended purpose

3.5.12
RESPONSIBLE BODY
individual or group responsible for the safe use and maintenance of equipment

3.5.13
WET LOCATION
location where water or another conductive liquid may be present and is likely to cause reduced human body impedance due to wetting of the contact between the human body and the equipment, or wetting of the contact between the human body and the environment

3.5.14
REASONABLY FORESEEABLE MISUSE
use of a product in a way not intended by the supplier, but which may result from readily predictable human behaviour

3.5.15
RISK
combination of the probability of occurrence of harm and the severity of that harm

3.5.16
TOLERABLE RISK
RISK which is accepted in a given context based on the current values of society

[ISO/IEC Guide 51:1999, 3.7]

3.5.17
OVERVOLTAGE CATEGORY
numeral defining a TRANSIENT OVERVOLTAGE condition (see Annex K)

3.5.18
TRANSIENT OVERVOLTAGE
short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[IEC 60050-604, Amendment 1:1998, 604-03-13]

3.5.19
TEMPORARY OVERVOLTAGE
power frequency overvoltage of relatively long duration

[IEC 60050-604, Amendment 1:1998, 604-03-12]

3.6 Insulation

3.6.1
BASIC INSULATION
insulation of HAZARDOUS LIVE parts which provides basic protection

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

NOTE BASIC INSULATION may serve also for functional purposes.

3.6.2
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

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

3.6.3
DOUBLE INSULATION
insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

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

3.6.4
REINFORCED INSULATION
insulation which provides protection against electric shock not less than that provided by DOUBLE INSULATION

NOTE REINFORCED INSULATION may be composed of several layers which cannot be tested singly as SUPPLEMENTARY INSULATION or BASIC INSULATION.

[IEC 60050-195:1998, 195-06-09, modified]

3.6.5
POLLUTION
addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity

3.6.6
POLLUTION DEGREE
numeral indicating the level of POLLUTION that may be present in the environment

3.6.7
POLLUTION DEGREE 1
no POLLUTION or only dry, non-conductive POLLUTION occurs, which has no influence

3.6.8
POLLUTION DEGREE 2
only non-conductive POLLUTION occurs except that occasionally a temporary conductivity caused by condensation is expected

3.6.9
POLLUTION DEGREE 3
conductive POLLUTION occurs, or dry, non-conductive POLLUTION occurs which becomes conductive due to condensation which is expected

NOTE In such conditions, equipment is normally protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity is controlled.

3.6.10
POLLUTION DEGREE 4
continuous conductivity occurs due to conductive dust, rain or other wet conditions

3.6.11
CLEARANCE
shortest distance in air between two conductive parts

3.6.12
CREEPAGE DISTANCE
shortest distance along the surface of a solid insulating material between two conductive parts

[IEC 60050-151:2001, 151-15-50]

3.101
AMBIENT TEMPERATURE
temperature, determined under specified conditions, of the air surrounding the equipment

3.102
ENCLOSED EQUIPMENT
equipment which includes an ENCLOSURE, having safety capability, or a combination of an ENCLOSURE, having safety capability, and installation provisions enclosing on all sides, with the possible exception of its mounting surface, to prevent personnel from accidentally touching HAZARDOUS LIVE, hot or moving parts contained therein and meeting requirements of mechanical strength, flammability, and stability (where applicable)

EXAMPLE HAND-HELD EQUIPMENT.

Note 1 to entry: This definition is related to IEC 60050-441:1984, 441-12-02.

3.103
FIELD WIRING
wiring of the control equipment, which is not installed in the control equipment manufacturer's facility

EXAMPLE MAINS supply wiring.

3.104
INTERFACE
shared boundary between one control equipment and another control equipment, or between parts of a control equipment, through which information or electrical energy is conveyed

[SOURCE: IEC 61131-2:2017, 3.1.21]

3.105
MODULAR EQUIPMENT
equipment consisting of different modules such as a Rack, CPU, different I/O-modules, network modules

Note 1 to entry: MODULAR EQUIPMENT CAN:

a) be OPEN EQUIPMENT or ENCLOSED EQUIPMENT;

b) consist of modules that cannot operate alone or of a basic module that is operational alone and can be enhanced in function by additional modules;

c) vary in size and functionality depending on the combination and the number of modules;

d) be combined with operational equipment or enhanced in function by the addition of modules by the customer.

3.106
OPEN EQUIPMENT
equipment which does not protect personnel from accidentally touching HAZARDOUS LIVE or moving parts contained therein nor meet requirements of mechanical strength, flammability and stability (where applicable)

Note 1 to entry: See Annex AA.

3.107
PANEL MOUNTED EQUIPMENT
equipment where a portion of the equipment may form part of the ENCLOSURE

Note 1 to entry: See Figure 103.

3.108
PORT
access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: PORT is most commonly used with respect to EMC.

3.109
PROTECTIVE EXTRA-LOW VOLTAGE CIRCUIT
PELV CIRCUIT
protective earth referenced electrical circuit in which the voltage cannot exceed the following:

NORMAL CONDITION and SINGLE FAULT CONDITION: The a.c. voltage levels are 30 V RMS, 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V RMS, 22,6 V peak and the d.c. voltage level is 35 V

Note 1 to entry: Transients are not taken into consideration in PELV CIRCUITS.

[SOURCE: IEC 60050-195:2021, 195-06-29, modified – In the preferred term, "system" has been replaced with "circuit", a full description and clarifications have been added and the Note to entry has been replaced with a new Note to entry.]

3.110
SAFETY EXTRA-LOW VOLTAGE CIRCUIT
SELV CIRCUIT
non-protective earth referenced electrical circuit in which the voltage cannot exceed the following:

NORMAL CONDITION and SINGLE FAULT CONDITION: The a.c. voltage levels are 30 V RMS, 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V RMS, 22,6 V peak and the d.c. voltage level is 35 V

Note 1 to entry: Transients are not taken into consideration in SELV CIRCUITS.

[SOURCE: IEC 60050-195:2021, 195-06-28, modified – In the preferred term, "system" has been replaced with "circuit", a full description and clarifications have been added and the Note to entry has been replaced with a new Note to entry.]

3.111
SERVICE PERSONNEL
person who is installing, changing or repairing the control equipment, with the appropriate technical training, experience and awareness of HAZARDS and of measures to minimize danger to themselves, other persons or to the control equipment, in an industrial environment

Note 1 to entry: SERVICE PERSONNEL are persons having the appropriate technical training and experience necessary to be aware of HAZARDS – e.g. electrical HAZARDS, temperature HAZARDS, fire HAZARDS – to which they are exposed in performing a task and of measures to minimize danger to themselves or to other persons or to the control equipment, in an industrial environment.

Note 2 to entry: SERVICE PERSONNEL change or repair control equipment e.g. hardware configuration or installation of software updates provided by the manufacturer.

Note 3 to entry: See AA.1.3 for more detail.

4 Tests

4.1 General

Tests in this standard are TYPE TESTS to be carried out on samples of equipment or parts. Their only purpose is to check that the design and construction ensure conformity with this standard. In addition, manufacturers shall perform the ROUTINE TESTS of Annex F on 100 % of equipment produced which has both HAZARDOUS LIVE parts and ACCESSIBLE conductive parts.

The equipment shall at least meet the requirements of this standard. It is permissible to exceed the requirements. If, in this standard, a lower limit is specified for a conformity value, then the equipment may demonstrate a larger value. If an upper limit is specified for a conformity value, the equipment may demonstrate a lower value.

Tests on subassemblies that meet the requirements of the relevant standards specified in this standard, and used in accordance with them, need not be repeated during TYPE TESTS of the whole equipment.

The product is verified in accordance with this document in a documented test configuration, which represents the least favourable configuration. See 4.3.

It is likely or possible that there are different test configurations which yield least favourable test conditions. For example there can be a least favourable configuration for the temperature test, and a different least favourable test configuration for the voltage test. If this is the case then the appropriate least favourable test configuration(s) shall be used with regard to 4.3.2 and 4.4.

These least favourable test configurations and test conditions shall be practical and useful for the intended applications.

Conformity with the requirements of this standard is checked by carrying out all applicable tests, except that a test may be omitted if examination of the equipment and design documentation demonstrates conclusively that the equipment would pass the test. Tests are carried out both under reference test conditions (see 4.3) and under fault conditions (see 4.4).

Where conformity statements in this standard require inspection, this may include examination of the equipment by measurement, examination of the markings on the equipment, examination of the instructions supplied with the equipment, examination of the data sheets of the materials or components from which the equipment is manufactured, etc. In each case, the inspection will either demonstrate that the equipment meets the applicable requirements, or will indicate that further testing is required.

Tests needed to support a RISK assessment (see Clause 17) are carried out in the combinations of conditions and operations determined during the RISK assessment.

If, when carrying out a conformity test, there is any uncertainty about the exact value of an applied or measured quantity (for example voltage) due to the tolerance:

a) manufacturers should ensure that at least the specified test value is applied;

b) test houses should ensure that no more than the specified test value is applied.

Conformity verification: The selected test configuration(s) and test conditions shall be documented with the rationale in the test report.

4.2 Sequence of tests

The sequence of tests is optional unless otherwise specified. The equipment under test shall be carefully inspected after each test. If the result of a test causes doubt whether any earlier tests would have been passed if the sequence had been reversed, these earlier tests shall be repeated.

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this standard, the following environmental conditions shall exist in the test location:

a) a temperature of 15 °C to 35 °C;

b) a relative humidity of not more than 75 %, but not exceeding the limits of 1.4.1 d);

c) an air pressure of 75 kPa to 106 kPa;

d) no hoar-frost, dew, percolating water, rain, solar radiation, etc.

4.3.2 State of equipment

4.3.2.1 General

Unless otherwise specified, each test shall be carried out on the equipment assembled for NORMAL USE and under the least favourable combination of the conditions given in 4.3.2.2 to 4.3.2.13.

NOTE In case of doubt, tests should be performed in more than one combination of conditions.

If dimensions or mass make it unsuitable to carry out particular tests on completely assembled equipment, tests on sub-assemblies are allowed, provided it is verified that the assembled equipment will meet the requirements of this standard.

4.3.2.2 Position of equipment

The equipment shall be in any position of NORMAL USE and with any ventilation unimpeded. Equipment intended to be built into a wall, recess, cabinet, etc., shall be installed as specified in the manufacturer's instructions.

4.3.2.3 Accessories

Accessories and OPERATOR-interchangeable parts available from, or recommended by, the manufacturer for use with the equipment under test shall be either connected or not connected.

4.3.2.4 Covers and removable parts

Covers or parts which can be removed without using a TOOL shall be removed or not removed.

4.3.2.5 MAINS supply

The following requirements apply.

a) The supply voltage shall be between 90 % and 110 % of any RATED supply voltage for which the equipment can be set or, if the equipment is RATED for a greater fluctuation, at any supply voltage within the fluctuation range.
b) The frequency shall be any RATED frequency.
c) Equipment for both a.c. and d.c. shall be connected to an a.c. or d.c. supply.
d) Equipment for single-phase a.c. supply shall be connected both with normal and reverse polarity.
e) If the means of connection permits reversal, battery-operated and d.c. equipment shall be connected with both reverse and normal polarity.

4.3.2.6 Input and output voltages

Input and output voltages, including floating voltages but excluding the MAINS supply voltage, shall be set to any voltage within the RATED voltage range.

4.3.2.7 Earth TERMINALS

PROTECTIVE CONDUCTOR TERMINALS, if any, shall be connected to earth.

FUNCTIONAL EARTH TERMINALS shall be connected or not connected to earth.

4.3.2.8 Controls

Controls which an OPERATOR can adjust without the use of a TOOL shall be set to any position except that:

a) MAINS selection devices shall be set to the correct value;
b) combinations of settings shall not be made if they are prohibited by the manufacturer's marking on the equipment.

4.3.2.9 Connections

The equipment shall be connected for NORMAL USE, or not connected.

4.3.2.10 Load on motors

Load conditions of motor-driven parts of equipment shall be in accordance with the NORMAL USE.

4.3.2.11 Output

For equipment giving an electrical output:

a) the equipment shall be operated in such a way as to provide the RATED output power to the RATED load;
b) the RATED load impedance of any output shall be connected or not connected.

4.3.2.12 Duty cycle

Equipment for short-term or intermittent operation shall be operated for the longest RATED period and shall have the shortest RATED recovery period consistent with the manufacturer's instructions.

Equipment for short-term or intermittent operation that develops significant heat during the startup phase, and that relies on continued operation to dissipate that heat, shall also be operated for the shortest RATED period followed by the shortest RATED recovery period.

4.3.2.13 Loading and filling

Equipment intended to be loaded with a specific material in NORMAL USE shall be loaded with the least favourable quantity of the materials specified in the instructions for use, including not loaded (empty) if the instructions for use permit this in NORMAL USE.

NOTE If the specified material could cause a HAZARD during test, another material may be used provided that it can be shown that the result of the test is not affected.

4.4 Testing in SINGLE FAULT CONDITION

4.4.1 General

The following requirements apply.

a) Examination of the equipment and its circuit diagram will generally show the fault conditions which are liable to result in HAZARDS and which, therefore, shall be applied.

   NOTE A fault condition can include open or short circuit of components, as well as disabling or bridging one means or layer of protection.

b) Fault tests shall be made as specified for checking conformity, unless it can be demonstrated that no HAZARD could arise from a particular fault condition.
c) The equipment shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they shall be recorded for each test. If the environmental limits of the reference test conditions (see 4.3) do not allow realistic assessment of SINGLE FAULT CONDITIONS, the test shall be conducted at the least favourable RATED environmental conditions of the equipment.

4.4.2 Application of fault conditions

4.4.2.1 General

Fault conditions shall include those specified in 4.4.2.2 to 4.4.2.14. They shall be applied only one at a time and shall be applied in turn in any convenient order. Multiple simultaneous faults shall not be applied unless they are a consequence of an applied fault.

NOTE For example, fans may be stopped one fan at a time unless they share a common power or control source. In that case, the common fans should be stopped simultaneously by interrupting the power or control source.

After each application of a fault condition, the equipment or part shall pass the applicable tests of 4.4.4.

4.4.2.2 PROTECTIVE IMPEDANCE

The following requirements apply.

a) If a PROTECTIVE IMPEDANCE is formed by a combination of components, each component shall be short-circuited or disconnected, whichever is less favourable.
b) If a PROTECTIVE IMPEDANCE is formed with a single component that meets the requirements of 6.5.4, it need not be short-circuited or disconnected.

4.4.2.3 Protective conductor

The protective conductor shall be interrupted, except for PERMANENTLY CONNECTED EQUIPMENT and equipment utilizing a connector meeting the requirements of IEC 60309.

4.4.2.4 Equipment or parts for short-term or intermittent operation

These shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITION. Individual parts may include motors, relays, other electromagnetic devices and heaters.

4.4.2.5 Motors

Motors shall be stopped while fully energized or prevented from starting, whichever is less favourable.

One supply phase of any multi-phase motor shall be interrupted while the motor is operating at its intended full load.

4.4.2.6 Capacitors

Capacitors (except for self-healing capacitors) in the auxiliary winding circuits of motors shall be short-circuited.

4.4.2.7 MAINS transformers

4.4.2.7.1 General

The secondary windings of MAINS transformers shall be short-circuited as specified in 4.4.2.7.2, and overloaded as specified in 4.4.2.7.3.

A transformer damaged during one test may be repaired or replaced before the next test.

Tests for MAINS transformers tested as separate components are specified in 14.6.

4.4.2.7.2 Short circuit

Each untapped output winding, and each section of a tapped output winding, which is loaded in NORMAL USE, shall be tested in turn, one at a time, to simulate short circuits in the load. Overcurrent protection devices remain fitted during the test. All other windings are loaded or not loaded, whichever load condition of NORMAL USE is less favourable.

4.4.2.7.3 Overload

Each untapped output winding, and each section of a tapped output winding, is overloaded in turn one at a time. The other windings are loaded or not loaded, whichever load condition of NORMAL USE is less favourable. If any overloads arise from testing in the fault conditions of 4.4, secondary windings shall be subjected to those overloads.

Overloading is carried out by connecting a variable resistor across the winding. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No further readjustments are then permitted.

If overcurrent protection is provided by a current-breaking device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 h. Before the test, the device is replaced by a link with negligible impedance. If this value cannot be derived from the specification, it is to be established by test.

For equipment in which the output voltage is designed to collapse when a specified overload current is reached, the overload is slowly increased to a point just before the point which causes the output voltage to collapse.

In all other cases, the loading is the maximum power output obtainable from the transformer.

Transformers with overtemperature protection which meets the requirements of 14.3 during the short-circuit test of 4.4.2.7.2 need not be subjected to overload tests.

4.4.2.8 Outputs

Outputs shall be short-circuited one at a time.

4.4.2.9 Equipment for more than one supply

Equipment which is designed to be operated from more than one type of supply shall be simultaneously connected to these supplies, unless this is prevented by the construction.

4.4.2.10 Cooling

Equipment cooling shall be restricted as follows, one fault at a time:

a) air-holes with filters shall be closed;
b) forced cooling by motor-driven fans shall be stopped;
c) cooling by circulation of water or other coolant shall be stopped;
d) loss of cooling liquid shall be simulated.

4.4.2.11 Heating devices

In equipment incorporating heating devices, the following faults shall be applied one at a time:

a) timers which limit the heating period shall be overridden to energize the heating circuit continuously;
b) temperature controllers, except for overtemperature protection devices meeting the requirements of 14.3, shall be overridden to energize the heating circuit continuously.

4.4.2.12 Insulation between circuits and parts

Insulation between circuits and parts which is below the level specified for BASIC INSULATION shall be bridged to check against the spread of fire if the method of 9.1 a) is used.

4.4.2.13 Interlocks

Each part of an interlock system for the protection of the OPERATOR shall be short-circuited or open-circuited in turn if the system prevents access to HAZARDS when a cover, etc. is removed without the use of a TOOL.

4.4.2.14 Voltage selectors

Voltage selectors which an OPERATOR can set for different RATED supply voltages shall be set for each possible setting with the equipment connected to each of its RATED supply circuits.

4.4.3 Duration of tests

4.4.3.1 General

The equipment shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to 1 h since a secondary fault arising from a SINGLE FAULT CONDITION will usually manifest itself within that time. If there is an indication that a HAZARD of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued for 4 h unless one of these HAZARDS arises before then.

4.4.3.2 Current limiting devices

If a device which interrupts or limits the current during operation is included to limit the temperature of parts which can easily be touched, the maximum temperature attained by those parts shall be measured, whether the device operates or not.

4.4.3.3 Fuses

If a fault is terminated by the opening of a fuse and if the fuse does not operate within approximately 1 s, the current through the fuse under the relevant fault condition shall be measured. The pre-arcing time/current characteristics of the fuse shall be evaluated to find out whether the minimum operating current is reached and what is the maximum time before the fuse operates. The current through the fuse may vary as a function of time.

If the minimum operating current of the fuse is not reached in the test, the equipment shall be operated for a period corresponding to the maximum fusing time or continuously for the duration specified in 4.4.3.1, with the fuse replaced with a short-circuit.

4.4.4 Conformity after application of fault conditions

4.4.4.1 General

Conformity with requirements for protection against electric shock after the application of single faults is checked as follows:

a) *by making the measurements of 6.3.2 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE;*

b) *by performing a voltage test on DOUBLE INSULATION or REINFORCED INSULATION to check that the protection is still at least at the level of BASIC INSULATION. The voltage tests are made as specified in 6.7 and 6.8 (without humidity preconditioning) with the test voltage for BASIC INSULATION;*

c) *by measuring the temperature of transformer windings if the protection against electrical HAZARDS is achieved by DOUBLE INSULATION or REINFORCED INSULATION within the transformer. The temperatures of Table 20 shall not be exceeded.*

4.4.4.2 Temperature

Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the ENCLOSURE and of parts which can easily be touched (See Clause 10).

4.4.4.3 Spread of fire

Conformity with requirements for protection against the spread of fire is checked by placing the equipment on white tissue-paper covering a softwood surface and covering the equipment with cheesecloth. 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 shall be ignored if no HAZARD could arise.

Optionally, for OPEN EQUIPMENT:

The equipment may be placed inside a wire mesh cage covered with cheesecloth. The wire mesh cage shall be maximum 1,5 times the size (length, width, height) of the device or representative system including the device, to simulate the intended ENCLOSURE during the single fault condition testing. See 10.4.1.101 for representative system methodology.with a tolerance of

The wire mesh cage shall be a metal screen with a mesh 25 mm × 25 mm with a tolerance of 5 mm, centre to centre with a wire diameter of 0,8 mm ± 0,3 mm.

NOTE 1 The wire mesh used is commonly known as chicken wire, 25 mm hexagonal mesh weave made of 0,81 gauge wire.

Cheesecloth is a bleached cotton cloth of approximately 40 g/m^2 containing no flame retardants.

NOTE 2 Cheesecloth is a coarse, loosely woven cotton gauze, originally used for wrapping cheese.

NOTE 3 Panel mounted equipment can combine the two methods.

4.4.4.4 Other HAZARDS

Conformity with other requirements for protection against HAZARDS is checked as specified in Clauses 7 to 16.

5 Marking and documentation

5.1 Marking

5.1.1 General

Equipment shall bear markings as specified in 5.1.2 to 5.2. Except for marking of internal parts, these markings shall be visible from the exterior, or be visible after removing a cover or opening a door without the aid of a TOOL, if the cover or door is intended to be removed or opened by an OPERATOR. Markings applying to the equipment as a whole shall not be put on parts which can be removed by an OPERATOR without the use of a TOOL.

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

Letter symbols for quantities and units shall be as specified in IEC 60027. Graphic symbols shall be in accordance with Table 1 if applicable. There are no colour requirements for symbols. Graphic symbols shall be explained in the documentation.

NOTE 1 IEC or ISO symbols should be used if available.

NOTE 2 Markings should not be on the bottom of the equipment, except on HAND-HELD EQUIPMENT or where space is limited.

Conformity is checked by inspection.

5.1.2 Identification

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

a) the name or trade mark of the manufacturer or supplier;

b) a model number, name or other means to identify the equipment. If equipment bearing the same distinctive designation (model number) is manufactured at more than one location, equipment from each manufacturing location shall be marked so that the location can be identified.

NOTE The marking of factory location may be in code and need not be on the equipment exterior.

Conformity is checked by inspection.

5.1.3 MAINS supply

The equipment shall be marked with the following information.

a) Nature of supply:

1) a.c.: RATED MAINS frequency or range of frequencies;

2) d.c.: symbol 1 of Table 1.

NOTE 1 For information purposes it may be useful to mark

– equipment intended for a.c. with symbol 2 of Table 1;

– equipment suitable for both a.c. and d.c. with symbol 3 of Table 1;

– equipment for three-phase supply with symbol 4 of Table 1.

b) The RATED supply voltage(s) or the RATED range of supply voltages.

NOTE 2 RATED voltage fluctuations may also be marked.

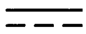
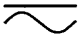
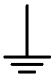
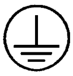
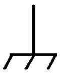
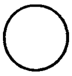
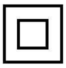
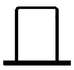
c) The maximum RATED power in watts (active power) or volt-amperes (apparent power), or the maximum RATED input current, with all accessories or plug-in modules connected. If the equipment can be used on more than one voltage range, separate values shall be marked for each voltage range unless the maximum and minimum values do not differ by more than 20 % of the mean value. The marked value shall not be less than 90 % of the maximum value.

d) Equipment which an OPERATOR can set for different RATED supply voltages shall be provided with means for the indication of the voltage for which the equipment is set. For PORTABLE EQUIPMENT the indication shall be visible from the exterior. If the equipment is so constructed that the supply voltage setting can be altered without the use of a TOOL, the action of changing the setting shall also change the indication.

e) Accessory MAINS socket-outlets accepting standard MAINS plugs shall be marked with the voltage if it is different from the MAINS supply voltage. If the outlet is for use only with specific equipment, it shall be marked to identify the equipment for which it is intended. If not, the maximum RATED current or power shall be marked, or symbol 14 of Table 1 placed beside the outlet with the full details included in the documentation.

Conformity is checked by inspection and by measurement of power or input current to check the requirements of 5.1.3 c) have been met. The measurement is made at each RATED voltage range with the equipment in the condition of maximum power or current consumption as applicable with all accessories and plug-in modules connected. If the input current varies during the normal operating cycle, the steady-state current is taken as the mean indication of the highest measured r.m.s. value during a 1 min period of the normal operation cycle. To *exclude any initial inrush current, the measurement is not made until the current has stabilized (usually after 1 min). Transients are ignored.*

Table 1 – Symbols

Number	Symbol	Reference	Description
1		IEC 60417-5031 (2002-10)	Direct current
2		IEC 60417-5032 (2002-10)	Alternating current
3		IEC 60417-5033 (2002-10)	Both direct and alternating current
4		IEC 60417-5032-1 (2002-10)	Three-phase alternating current
5		IEC 60417-5017 (2006-08)	Earth (ground) TERMINAL
6		IEC 60417-5019 (2006-08)	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 60417-5020 (2002-10)	Frame or chassis TERMINAL
8			Not used
9		IEC 60417-5007 (2009-02)	On (Power)
10		IEC 60417-5008 (2009-02)	Off (Power)
11		IEC 60417-5172 (2003-02)	Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
12			Caution, possibility of electric shock
13		IEC 60417-5041 (2002-10)	Caution, hot surface
14		ISO 7000-0434A: 2004-01 or ISO 7000-0434B: 2004-01	Caution
15		IEC 60417-5268 (2002-10)	In position of a bi-stable push control
16		IEC 60417-5269 (2002-10)	Out position of a bi-stable push control
17		ISO 361	Ionizing radiation

[a] See 5.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.

5.1.4 Fuses

For any fuse which may be replaced by an OPERATOR, there shall be a marking beside the fuseholder, which will enable the OPERATOR to identify the correct replacement fuse (see 5.4.5).

Conformity is checked by inspection.

5.1.5 TERMINALS, connections and operating devices

5.1.5.1 General

If necessary for safety, an indication shall be given of the purpose of TERMINALS, connectors, controls, and indicators, including any connections for fluids such as gas, water and drainage. Where there is insufficient space, symbol 14 of Table 1 may be used.

NOTE 1 For additional information, see IEC 60445 and IEC 60447.

NOTE 2 Individual pins of multi-pin connectors need not be marked.

Push-buttons and actuators of emergency stop devices, and indicators used only to indicate a warning of danger or the need for urgent action, shall be coloured red and coded as specified in IEC 60073. If the meaning of colour relates to the safety of persons or the environment, supplementary means of coding shall be provided (see IEC 60073).

NOTE 3 National authorities may require that equipment used in certain environments meet the man-machine interface requirements pertinent to that environment.

Conformity is checked by inspection.

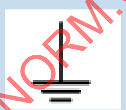
5.1.5.2 TERMINALS

TERMINALS for connection to the MAINS supply shall be identifiable.

The following TERMINALS shall be marked as follows:

a) FUNCTIONAL EARTH TERMINALS (i.e. used for non-safety purposes such as interference immunity improvement) shall be marked with one of the following symbols;

 IEC 60417-5018 (2011-07) or

 IEC 61010-1:2010, symbol 5 of Table 1, IEC 60417-5017 (2006-08).

Where a TERMINAL serves both as the PROTECTIVE CONDUCTOR TERMINAL and as a FUNCTIONAL EARTH TERMINAL, symbol 6 of Table 1 and other requirements for PROTECTIVE CONDUCTOR TERMINAL shall be applied. Where a TERMINAL serves both as an earth (ground) TERMINAL and FUNCTIONAL EARTH TERMINAL, symbol 5 of Table 1 and other requirements for earth TERMINALS shall be applied.

b) PROTECTIVE CONDUCTOR TERMINALS with symbol 6 of Table 1, except when the PROTECTIVE CONDUCTOR TERMINAL is part of an approved MAINS appliance inlet. The symbol shall be placed on the TERMINAL or close to it;

c) TERMINALS of circuits which are permitted by 6.6.3 to be connected to ACCESSIBLE conductive parts, with symbol 7 of Table 1 unless connection is self-evident;

NOTE This symbol may also be considered as a warning symbol in that it indicates that a HAZARDOUS LIVE voltage must not be connected to the TERMINAL. The symbol should also be used if it is likely that an OPERATOR could make such a connection inadvertently.

d) TERMINALS supplied from the interior of the equipment and which are HAZARDOUS LIVE, with the voltage, current, charge or energy value or range, or with symbol 14 of Table 1. This requirement does not apply to MAINS supply outlets where a standard MAINS socket outlet is used.

aa) If a TERMINAL has a hazardous voltage level, the TERMINAL shall be marked with symbol 14 of Table 1.

Conformity is checked by inspection.

5.1.6 Switches and circuit-breakers

If the power supply switch or circuit-breaker is used as the disconnecting device, the off-position shall be clearly marked.

NOTE It is recommended that the on-position also be marked.

Symbols 9 and 10 of Table 1 can, in some cases, also be suitable as the device identification (see 6.11.3.1 c)). A lamp alone is not considered to be a satisfactory marking.

If a push-button switch is used as the power supply switch, symbols 9 and 15 of Table 1 may be used to indicate the on-position, or symbols 10 and 16 to indicate the off-position, with the pair of symbols (9 and 15, or 10 and 16) close together.

Conformity is checked by inspection.

5.1.7 Equipment protected by DOUBLE INSULATION or REINFORCED INSULATION

Equipment which is only partially protected by DOUBLE INSULATION or REINFORCED INSULATION shall not be marked with symbol 11 of Table 1.

NOTE Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION may be marked with symbol 11 of Table 1.

Conformity is checked by inspection.

5.1.8 Field-wiring TERMINAL boxes

If the temperature of the TERMINALS or the ENCLOSURE of a field-wiring TERMINAL box or compartment exceeds 60 °C in NORMAL CONDITION at an ambient temperature of 40 °C, or at the maximum RATED ambient temperature if higher, there shall be a marking to warn the installer to consult the installation instructions before determining the temperature RATING of the cable to be connected to the TERMINALS. The marking shall be visible before and during connection, or be beside the TERMINALS. Symbol 14 is an acceptable marking.

A FIELD WIRING TERMINAL need not be marked to indicate the temperature RATING if it is intended for the connection of a control circuit conductor only.

A control circuit is any circuit that does not carry MAINS power and is generally limited to 15 A.

Conformity, in case of doubt, is checked by measurement as specified in 10.3 a) and, if applicable, by inspection of markings.

5.2 Warning markings

Warning markings specified in this standard shall meet the following requirements.

Warning markings shall be visible when the equipment is ready for NORMAL USE. If a warning applies to a particular part of the equipment, the marking shall be placed on or near that part.

The size of warning markings shall be as follows:

a) symbols shall be at least 2,75 mm high. Text shall be at least 1,5 mm high and contrast in colour with the background;

b) symbols or text moulded, stamped or engraved in a material shall be at least 2,0 mm high. If not contrasting in colour, they shall have a depth or raised height of at least 0,5 mm.

If it is necessary for the RESPONSIBLE BODY or OPERATOR to refer to the documentation to preserve the protection afforded by the equipment, the equipment shall be marked with symbol 14 of Table 1. Symbol 14 is not required to be used if other symbols which address the safety aspects are used and explained in the documentation.

If the instructions for use state that an OPERATOR is permitted to gain access, using a TOOL, to a part or location which in NORMAL USE may present a HAZARD, there shall be a warning marking indicating that the equipment must be placed in a safe state before access. Symbol 14 shall be used for this purpose with the warning text included in the documentation. Additional symbols may be used to indicate the nature of the HAZARD such as symbol 12, 13, or 17 as appropriate.

Symbols are the preferred marking method over text warnings. Supplemental text may be provided adjacent to the symbol.

Conformity is checked by inspection.

5.3 Durability of markings

Required markings shall remain clear and legible under conditions of NORMAL USE and shall resist the effects of the cleaning agents specified by the manufacturer.

Conformity is checked by performing the following test for durability of markings on the outside of the equipment. The markings are rubbed by hand, without undue pressure, for 30 s with a cloth soaked with each specified cleaning agent (or, if not specified, with 70 % isopropyl alcohol).

After the above treatment the markings shall be clearly legible and adhesive labels shall not have worked loose or become curled at the edges.

5.4 Documentation

5.4.1 General

The following documentation necessary for safety purposes, as needed by the OPERATOR or the RESPONSIBLE BODY, shall be provided with the equipment. Safety documentation for service personnel authorized by the manufacturer shall be made available to such personnel:

a) intended use of the equipment;
b) technical specification;
c) name and address of the manufacturer or supplier from whom technical assistance may be obtained;
d) the information specified in 5.4.2 to 5.4.6;
e) information about how to mitigate RISKS remaining after a RISK assessment has been performed (see Clause 17);
f) for equipment which for safety reasons requires specific accessories (for example probe assemblies) with specific characteristics, the documentation shall indicate that only accessories which meet the manufacturer's specifications shall be used;

g) if a HAZARD could be caused by an incorrect reading when measuring, indicating or detecting harmful or corrosive substances, or HAZARDOUS LIVE electrical quantities, the instructions shall provide guidance on how to determine that the equipment is functioning correctly;

h) instructions for lifting and carrying (see 7.5.1).

Warning symbols and warning statements that are marked on the equipment shall be explained in the documentation. In particular, the documentation shall include a statement that it must be consulted in all cases where symbol 14 of Table 1 is marked, in order to find out the nature of the potential HAZARDS and any actions which have to be taken to avoid them.

NOTE 1 Markings and text on equipment are considered equivalent to the documentation.

NOTE 2 If NORMAL USE involves the handling of harmful or corrosive substances, instruction should be given on correct use and safety provisions. If any harmful or corrosive substance is specified or supplied by the equipment manufacturer, the necessary information on its constituents and the correct disposal procedure should also be given.

Documentation may be provided on printed or electronic media, however printed information is required for all information necessary for safety that might not be available in electronic form at the time it is needed. The documentation shall be delivered with the equipment. Consideration shall be given to the ability of the RESPONSIBLE BODY to read the media.

For equipment intended to be installed by SERVICE PERSONNEL or trained installers, all documentation may be provided by electronic media.

Where the documentation is provided by electronic media, this may be accomplished by including symbol 14 of Table 1, on the product, and the location of the documentation, for example URL, QRcode, on the product, packaging or printed information with the product.

Annex EE provides details on the flow of information, regarding safety aspects, for controls and its accessory in an industrial use.

Conformity is checked by inspection.

5.4.2 Equipment RATINGS

Documentation shall include the following:

a) the supply voltage or voltage range, frequency or frequency range, and power or current RATING;

b) a description of all input and output connections as required by 6.6.1 a);

c) the rating of the insulation of external circuits as required by 6.6.1 b);

d) a statement of the range of environmental conditions for which the equipment is designed including:

   1) indoor or outdoor use,

   2) altitude,

   3) temperature,

   4) relative humidity,

   5) MAINS supply voltage fluctuations,

   6) OVERVOLTAGE CATEGORY, except for cord/plug-connected equipment,

   7) WET LOCATION, if applicable,

   8) POLLUTION DEGREE of the intended environment,

e) for equipment RATED for ingress protection according to IEC 60529 the information required in 11.6.1;

f) for equipment with an impact RATING less than 5 J, the information specified in 8.1 d).

aa) digital input devices shall be rated in volts and shall also indicate whether the input device is intended for direct or alternating current;

bb) analogue input and analogue output devices shall be rated in the voltage range or current range, or both, as applicable;

cc) digital and switching output devices shall be rated in voltage and one or more of the following depending on intended load type:

1) general purpose: amperes;

2) coil: code designation, volt-amperes, amperes and inrush amperes; or amperes and the words "pilot duty";

3) resistance: amperes, resistance, only;

4) resistive heating: amperes, resistive heating;

5) incandescent lamp: amperes or watts, tungsten;

6) ballast (electric discharge lamp): amperes, ballast;

7) ballast, electronic (electric discharge lamp): amperes, electronic fluorescent ballast;

8) motor: horsepower or full-load current and locked-rotor current;

9) a device intended for control of a specific load type not addressed above shall be marked to indicate the specific load type in standard terminology;

dd) a device which is intended for use with a specific model load (e.g. specific motor or coil) or input sourcing device (e.g. specific transducer or power supply) shall be documented with the manufacturer's name and model number of the device with which it is intended to be used.

Conformity is checked by inspection.

5.4.3 Equipment installation

The documentation shall include installation and specific commissioning instructions and, if necessary for safety, warnings against HAZARDS which could arise during installation or commissioning or as a result of improper installation or commissioning of the equipment. Such information includes, if applicable:

a) assembly, location and mounting requirements;

b) instructions for protective earthing;

c) connections to the supply;

d) for PERMANENTLY CONNECTED EQUIPMENT:

1) supply and FIELD WIRING requirements, for example insulation, temperature RATING;

2) requirements for any external switch or circuit-breaker (see 6.11.3.1) and external overcurrent protection devices (see 9.6.2) and a recommendation that the switch or circuit-breaker be near the equipment;

e) ventilation requirements;

f) requirements and safety characteristics for special external services, for example: maximum and minimum temperature, pressure, or flow of air or cooling liquid;

g) instructions relating to sound level (see 12.5.1).

aa) OPEN EQUIPMENT: If the control equipment is evaluated in accordance with 9.1.c) and 9.3.2 for hazards related to the spread of fire (containment of fire within the equipment, if it occurs), it can be necessary for the installation documentation to specify necessary constructional requirements applicable for the end use location, for example acceptable ventilation openings, as applicable.

NOTE 101 See also 7.1.101, 8.1.101 and 9.3.2.

NOTE 102 Subclause 9.1 states that it is possible for different circuits or parts of the equipment to be evaluated to different methods (9.1 a), b) or c)).

NOTE It is recommended to add a statement in the documentation for the installation that the safety of any system incorporating the equipment is the responsibility of the assembler of the system.

Conformity is checked by inspection.

5.4.4 Equipment operation

Instructions for use shall include, if applicable:

a) identification and description of operating controls and their use in all operating modes;
b) instructions not to position the equipment so that it is difficult to operate the disconnecting device;
c) instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;
d) specifications of limits for intermittent operation;
e) explanations of symbols related to safety which are used on the equipment;
f) instructions for replacement of consumable materials;
g) instructions for cleaning and decontamination;
h) a statement listing potentially poisonous or injurious substances that can be liberated from the equipment, and possible quantities;
i) detailed instructions about RISK reduction procedures relating to flammable liquids (see 9.5 c));
j) details of methods of reducing the RISKS of burns from surfaces permitted to exceed the temperature limits of 10.1, Table 19.

If equipment conforming to IEC 60950 is used with equipment conforming to this standard, and if there is a HAZARD due to moisture or liquids, the instructions for use shall specify any additional precautions necessary.

There shall be a statement in the instructions that, if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Conformity is checked by inspection.

5.4.5 Equipment maintenance and service

Instructions shall be provided to the RESPONSIBLE BODY in sufficient detail to permit safe maintenance, inspection and testing of the equipment, and to ensure continued safety of the equipment after the maintenance, inspection and test procedure.

If applicable, manufacturer's documentation shall instruct against replacing detachable MAINS supply cords by inadequately RATED cords.

For equipment using replaceable batteries, the specific battery type shall be stated.

The manufacturer shall specify any parts which are required to be examined or supplied only by the manufacturer or his agent.

The RATING and characteristics of replaceable fuses shall be stated.

Instructions on the following subjects shall be provided for service personnel, as necessary to permit safe servicing and continued safety of the equipment after servicing if the equipment is suitable to be serviced:

a) product-specific RISKS that may affect the service personnel;
b) protective measures for these RISKS;
c) verification of the safe state of the equipment after repair.

NOTE Instructions for service personnel need not be supplied to the RESPONSIBLE BODY, but should be made available to service personnel.

Conformity is checked by inspection.

5.4.6 Integration into systems or effects resulting from special conditions

Aspects resulting from integration into systems or effects resulting from special ambient or application conditions shall be described in the documentation.

Conformity is checked by inspection of the documentation.

6 Protection against electric shock

6.1 General

6.1.1 Requirements

Protection against electric shock shall be maintained in NORMAL CONDITION and SINGLE FAULT CONDITION (see 6.4 and 6.5). ACCESSIBLE parts (see 6.2) shall not be HAZARDOUS LIVE (see 6.3). Voltage, current, charge or energy between an ACCESSIBLE part and earth, or between any two ACCESSIBLE parts on the same piece of equipment within a distance of 1,8 m (over a surface or through air), shall not exceed the levels of 6.3.1 in NORMAL CONDITION nor of 6.3.2 in SINGLE FAULT CONDITION.

Conformity is checked by the determination of ACCESSIBLE parts as specified in 6.2 and by the measurements of 6.3 to establish that the levels of 6.3.1 and 6.3.2 are not exceeded, followed by the tests of 6.4 to 6.11.

6.1.2 Exceptions

If it is not feasible for operating reasons to prevent the following parts being both ACCESSIBLE and HAZARDOUS LIVE, they are permitted to be ACCESSIBLE to SERVICE PERSONNEL during NORMAL USE while they are HAZARDOUS LIVE:

For example:

a) parts of lamps and lamp sockets after lamp removal;
b) parts intended to be replaced by SERVICE PERSONNEL (e.g. batteries) and which can be HAZARDOUS LIVE during the replacement or other SERVICE PERSONNEL action, but only if they are ACCESSIBLE only by means of a TOOL and have a warning marking (see 5.2).

If any of the parts in examples a) and b) receive a charge from an internal capacitor, they shall not be HAZARDOUS LIVE 10 s after interruption of the supply.

If a charge is received from an internal capacitor, conformity is checked by the measurements of 6.3 to establish that the levels of 6.3.1 c) are not exceeded.

6.2 Determination of ACCESSIBLE parts

6.2.1 General

IEC 61010-1:2010, Subclause 6.2.1 and IEC 61010-1:2010/AMD1:2016, Subclause 6.2.1 are applicable to ENCLOSED EQUIPMENT.

Unless obvious, determination of whether a part is ACCESSIBLE is made as specified in 6.2.2 to 6.2.4 in all positions of NORMAL USE. Test fingers (see Annex B) and pins are applied without force unless a force is specified. Parts are considered to be ACCESSIBLE if they can be touched with any part of a test finger or test pin, or if they could be touched in the absence of a covering which is not considered to provide suitable insulation (see 6.9.2).

If, in NORMAL USE, an OPERATOR is intended to perform any actions (with or without a TOOL) that could increase the accessibility of parts, such actions are taken before performing the examinations of 6.2.2 to 6.2.4.

NOTE Examples of such actions include:

a) removing covers;

b) opening doors;

c) adjusting controls;

d) replacing consumable material;

e) removing parts.

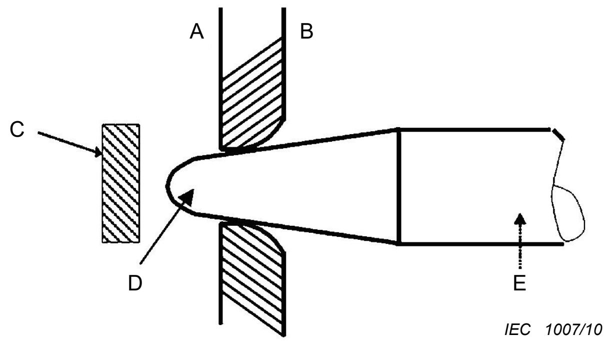
Rack-mounted and panel-mounted equipment is installed as specified in the manufacturer's instructions before making the examinations of 6.2.2 to 6.2.4. For such equipment, the OPERATOR is assumed to be in front of the panel.

6.2.2 Examination

IEC 61010-1:2010, Subclause 6.2.2 is applicable to ENCLOSED EQUIPMENT.

The jointed test finger (see Figure B.2) is applied in every possible position. If a part could become ACCESSIBLE by applying a force, the rigid test finger (see Figure B.1) is applied with a force of 10 N. The force is exerted by the tip of the test finger so as to avoid wedge and lever action. The test is applied to all outer surfaces, including the bottom. However, on equipment accepting plug-in modules the tip of the jointed test finger is inserted only to a depth of 180 mm from the opening in the equipment.

The test finger is likewise applied to all openings in the ENCLOSURE, including holes and TERMINALS. In these cases, the ACCESSIBLE parts of the ENCLOSURE are considered to include any part of the test finger which can be inserted into the hole or TERMINAL (see Figure 1).



Key

A inside of equipment

B outside of equipment

C HAZARDOUS LIVE part

D tip of test finger is considered to be ACCESSIBLE

E test finger

Figure 1 – Measurements through openings in ENCLOSURES

6.2.3 Openings above parts that are HAZARDOUS LIVE

IEC 61010-1:2010, Subclause 6.2.3 is applicable to ENCLOSED EQUIPMENT.

A metal test pin 100 mm long and 4 mm in diameter is inserted into any openings above parts which are HAZARDOUS LIVE. The test pin is suspended freely and allowed to penetrate up to 100 mm.

The additional safety measures of 6.5.1 for protection in SINGLE FAULT CONDITION are not required solely because a part is ACCESSIBLE only by this test.

NOTE This exception is permitted because the insertion of an object similar to this test pin is considered to be a SINGLE FAULT CONDITION and one means of protection is sufficient.

This test is not applied to TERMINALS.

6.2.4 Openings for pre-set controls

IEC 61010-1:2010, Subclause 6.2.4 is applicable to ENCLOSED EQUIPMENT. This subclause applies to SERVICE PERSONNEL only.

A metal test pin 3 mm in diameter is inserted through holes intended to give access to pre-set controls which require the use of a screwdriver or other TOOL. The test pin is applied in every possible direction through the hole. Penetration shall not exceed three times the distance from the ENCLOSURE surface to the control shaft or 100 mm, whichever is smaller.

6.2.101 Accessibility of INTERFACES, PORTS and TERMINALS

INTERFACES, PORTS and TERMINALS, as listed in Table 101, shall be prevented from becoming both OPERATOR ACCESSIBLE AND HAZARDOUS LIVE UNDER NORMAL AND SINGLE-FAULT CONDITIONS.

Other than for Ports Ar, Be and E, protection can generally be achieved by making the HAZARDOUS LIVE parts, of the INTERFACE, PORT or TERMINAL, not ACCESSIBLE.

See also Figure 101.

Table 101 – INTERFACES, PORTS AND TERMINALS considered as OPERATOR ACCESSIBLE for OPEN and ENCLOSED EQUIPMENT

INTERFACES, PORTS and TERMINALS		CONSIDERED AS OPERATOR ACCESSIBLE	
		OPEN EQUIPMENT[c]	ENCLOSED EQUIPMENT[d]
Al	communication INTERFACE/PORT for local extension rack	No	Yes
Ar	communication INTERFACE/PORT for remote devices (e.g. IO station, control network, fieldbus)[a]	Yes	Yes
Be	open communication INTERFACE/PORT, also open to third-party devices (e.g. PADT, personal computer used for programming)[a]	Yes	Yes
Bi	internal communication INTERFACE/PORT for peripherals	No	Not applicable[b]
C	INTERFACE/PORT for digital and analogue input signals	No	Yes
D	INTERFACE/PORT for digital and analogue output signals	No	Yes
E	serial or parallel communication INTERFACES/PORTS for data communication with third-party devices (e.g. computers and printers)[a]	Yes	Yes
F	equipment power input INTERFACE/PORT	No	Yes
G	PROTECTIVE EARTH TERMINAL	No	Yes
H	FUNCTIONAL EARTH TERMINAL/PORT	No	Yes
J	I/O power input INTERFACE/PORT	No	Yes
K	auxiliary power output INTERFACE/PORT for external devices (e.g. to supply sensors, actuators, HMI)	No	Yes

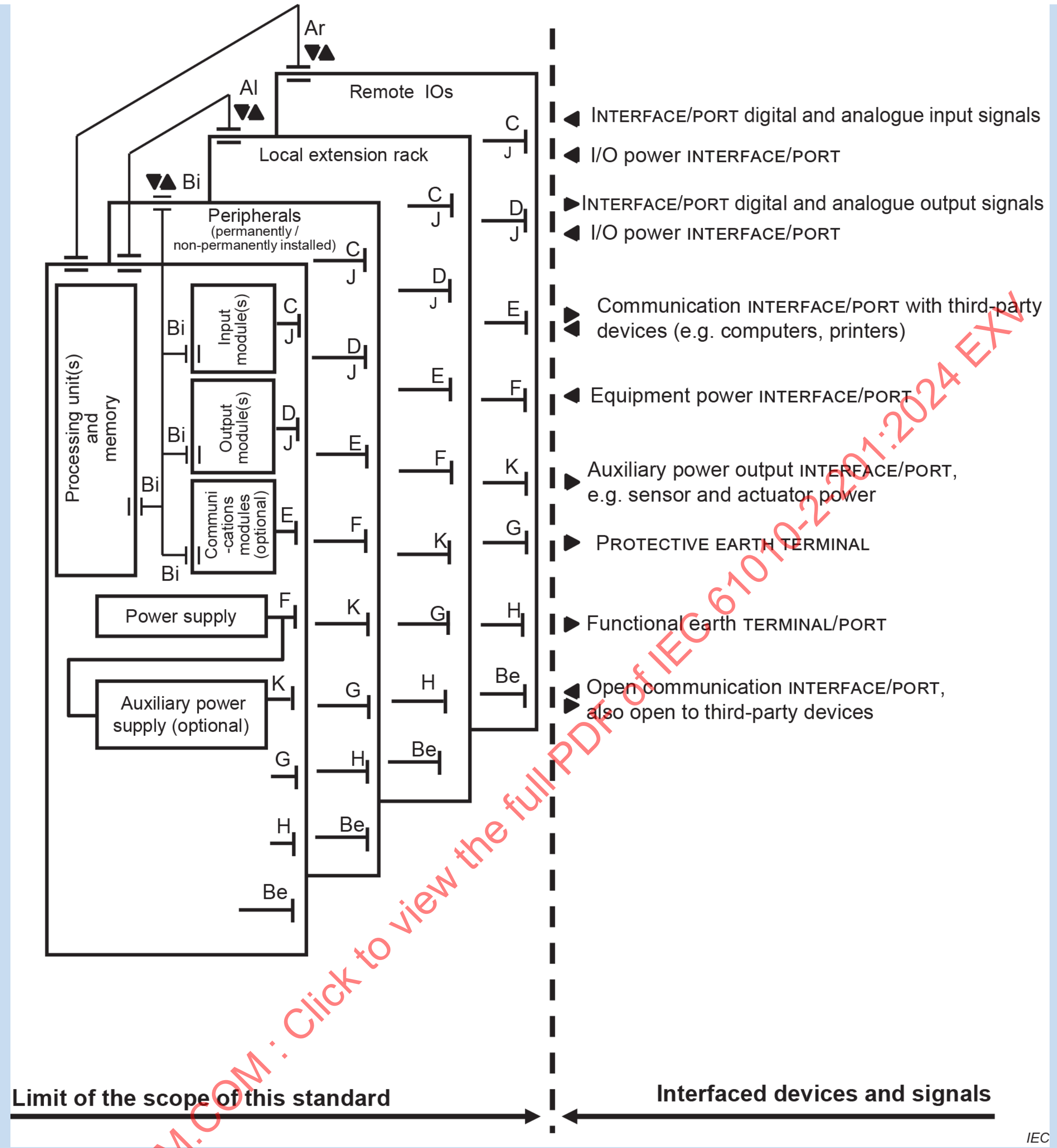
NOTE INTERFACE/PORT/TERMINAL designation as used in this table, is aligned with the IEC 61131 series.

[a] Ports Ar, Be and E contain circuits which may be connected to other equipment, where the remote side of the connecting cable can be ACCESSIBLE, and require therefore to be considered for OPEN EQUIPMENT.

[b] Port Bi is an internal communication port and thus never leaves the ENCLOSED EQUIPMENT, by definition.

[c] Depending on the intended use of the connected equipment, INTERFACES/PORTS of OPEN EQUIPMENT shall be considered OPERATOR ACCESSIBLE, when the remote side of the connecting cable or circuit can be ACCESSIBLE.

[d] Depending on the intended use of the connected equipment, INTERFACES/PORTS of ENCLOSED EQUIPMENT may be considered as not OPERATOR ACCESSIBLE, where the construction of the INTERFACE/PORT and the remote side of the connecting cable or circuit are not ACCESSIBLE.



Key

Al Communication INTERFACE/PORT for local extension rack

Ar Communication INTERFACE/PORT for remote I/O station, control network, fieldbus

Be Open communication INTERFACE/PORT, open to third-party devices, e.g. PADT, personal computer used for programming

Bi Internal communication INTERFACE/PORT, e.g. backplane bus

C Interface/port for digital and analog input signals

D Interface/port for digital and analog output signals

E Serial or parallel communication INTERFACES/PORTS for data communication with third-party devices, e.g. computers, printers

F Equipment power INTERFACE/PORT

G PROTECTIVE EARTH TERMINAL/PORT

H FUNCTIONAL EARTH TERMINAL/PORT

J I/O power INTERFACE/PORT

K Auxiliary power output INTERFACE/PORT, e.g. sensor and actuators power

Figure 101 – Typical INTERFACE/PORT of control equipment

Conformity is checked by inspection and in case of doubt by measurement and test in accordance with 6.2 and 6.3.

6.2.102 Control equipment

6.2.102.1 ACCESSIBLE parts

ACCESSIBLE parts of control equipment shall not be, or in the case of a single fault become, HAZARDOUS LIVE. Although these requirements are principally directed at ENCLOSED EQUIPMENT, these requirements also apply to OPEN EQUIPMENT. When applied to OPEN EQUIPMENT, the control equipment shall be considered to be installed in accordance with the installation instructions. Also see 5.4.3 and Annex AA.

If SERVICE PERSONNEL are required to make adjustments, etc., for example during the commissioning of OPEN EQUIPMENT, then protection from HAZARDS in the area near the adjustment shall be provided to prevent contact. If the HAZARD is not indicated by a warning label (see 5.2) then other protective means, for example ENCLOSURE or PROTECTIVE BARRIER is required.

Conformity is checked by inspection and examination in accordance with 6.2.2.

6.2.102.2 SELV/PELV CIRCUITS

SELV/PELV CIRCUITS do not require additional evaluation for RISK against electrical shock, provided that those circuits are in dry locations.

6.3 Limit values for ACCESSIBLE parts

6.3.1 Levels in NORMAL CONDITION

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) The a.c. voltage levels are 30 V r.m.s., 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V r.m.s., 22,6 V peak and the d.c.voltage level is 35 V.

b) The current levels are:

   1) 0,5 mA r.m.s. for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.4 is used for equipment intended for use in WET LOCATIONS.

   2) 70 mA r.m.s. when measured with the measuring circuit of Figure A.3. This relates to possible burns at higher frequencies.

c) The levels of capacitive charge or energy are:

   1) 45 μC charge for voltages up to 15 kV peak or d.c.; line A of Figure 3 shows the capacitance versus voltage where the charge is 45 μC.

   2) 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.2 Levels in SINGLE FAULT CONDITION

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.

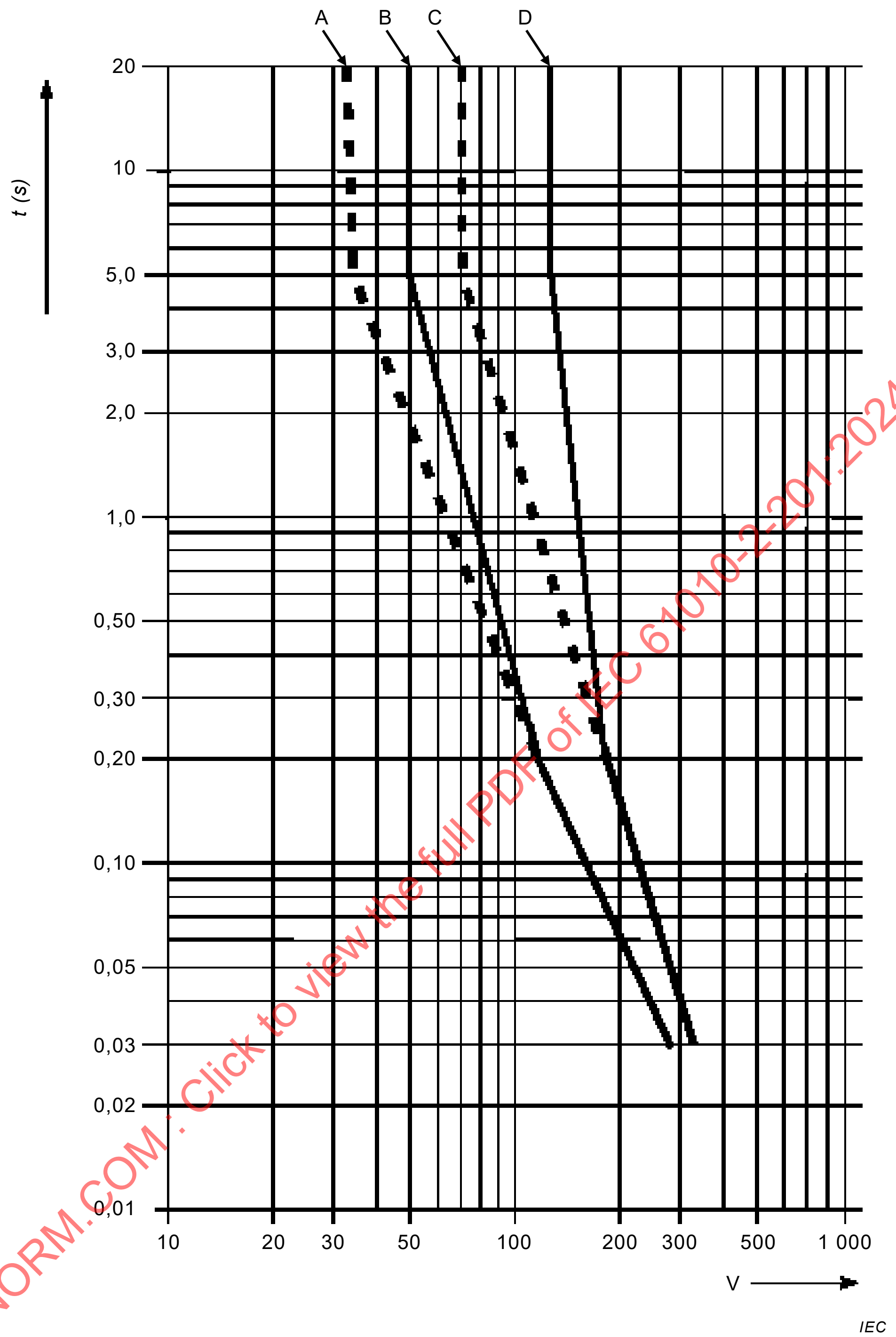
a) The a.c. voltage levels are 50 V r.m.s., 70 V peak and the d.c. voltage level is 120 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 33 V r.m.s, 46,7 V peak and the d.c. voltage level is 70 V . For voltages of short duration, the duration versus voltage levels are those of Figure 2, measured across a 50 kΩ resistor.

b) The current levels are:

3) 3,5 mA r.m.s. for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.4 is used for equipment intended for use in WET LOCATIONS;

4) 500 mA r.m.s. when measured with the measuring circuit of Figure A.3. This relates to possible burns at higher frequencies.

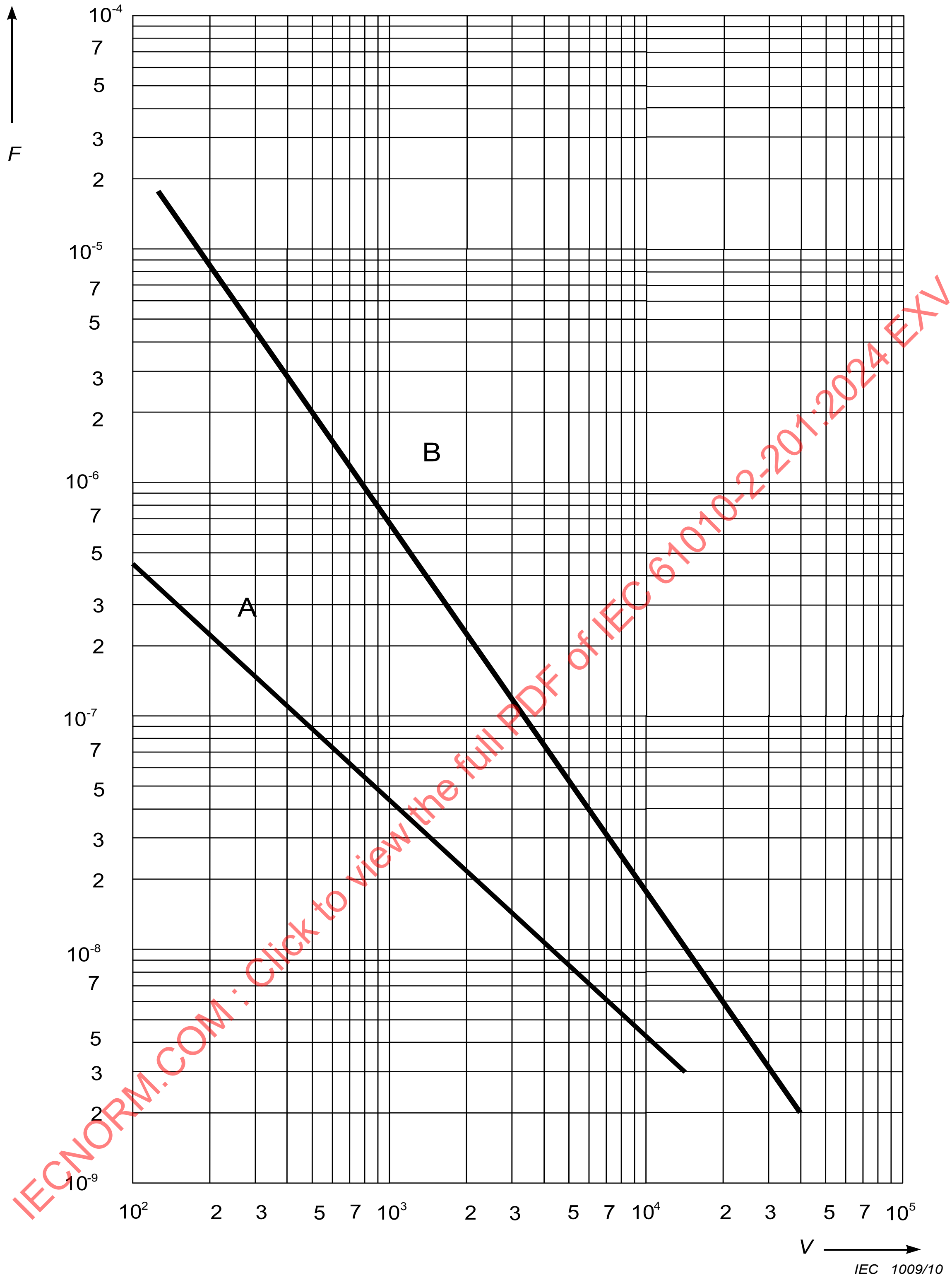
c) The capacitance level is line B of Figure 3.



Key

A	a.c. voltage level in WET LOCATIONS	C	d.c. voltage level in WET LOCATIONS
B	a.c. voltage level in dry locations	D	d.c. voltage level in dry locations

Figure 102 – Maximum duration of short-term ACCESSIBLE voltages in SINGLE FAULT CONDITION (see 6.3.2 a))



Key

A NORMAL CONDITION

B SINGLE FAULT CONDITION

Figure 103 – Capacitance level versus voltage in NORMAL CONDITION and SINGLE FAULT CONDITION (see 6.3.1 c) and 6.3.2 c))

6.4 Primary means of protection

6.4.1 General

ACCESSIBLE parts shall be prevented from becoming HAZARDOUS LIVE by one or more of the following means (see Annex D):

a) ENCLOSURES or PROTECTIVE BARRIERS (see 6.4.2);

b) BASIC INSULATION (see 6.4.3);

c) impedance (see 6.4.4).

Conformity is checked by inspection and as specified in 6.4.2. to 6.4.4.

6.4.2 ENCLOSURES and PROTECTIVE BARRIERS

ENCLOSURES and PROTECTIVE BARRIERS shall meet the rigidity requirements of 8.1.

If ENCLOSURES or PROTECTIVE BARRIERS provide protection by insulation, they shall meet the requirements of BASIC INSULATION.

If ENCLOSURES or PROTECTIVE BARRIERS provide protection by limiting access, CLEARANCES and CREEPAGE DISTANCES between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.7 and the applicable requirements for BASIC INSULATION.

Conformity is checked as specified in 6.7 and 8.1.

6.4.3 BASIC INSULATION

CLEARANCES, CREEPAGE DISTANCES and solid insulation forming BASIC INSULATION between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.7.

Conformity is checked as specified in 6.7.

6.4.4 Impedance

An impedance used as a primary means of protection shall meet all the following requirements:

a) it shall limit the current or voltage to not more than the applicable level of 6.3.2;

b) it shall be RATED for the maximum WORKING VOLTAGE and for the amount of power that it will dissipate;

c) CLEARANCE and CREEPAGE DISTANCE between terminations of the impedance shall meet the applicable requirements of 6.7 for BASIC INSULATION.

Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 6.3.2, and by measuring CLEARANCE and CREEPAGE DISTANCE as specified in 6.7.

6.5 Additional means of protection in case of SINGLE FAULT CONDITIONS

6.5.1 General

ACCESSIBLE parts shall be prevented from becoming HAZARDOUS LIVE in SINGLE FAULT CONDITION. The primary means of protection (see 6.4) shall be supplemented by one of a), b), c) or d). Alternatively one of the single means of protection e) or f) shall be used. See Figure 4 and Annex D.

a) PROTECTIVE BONDING (see 6.5.2);

b) SUPPLEMENTARY INSULATION (see 6.5.3);

c) automatic disconnection of the supply (see 6.5.5);
d) current- or voltage-limiting device (see 6.5.6);
e) REINFORCED INSULATION (see 6.5.3);
f) PROTECTIVE IMPEDANCE (see 6.5.4).

Conformity is checked by inspection and as specified in 6.5.2 to 6.5.6.

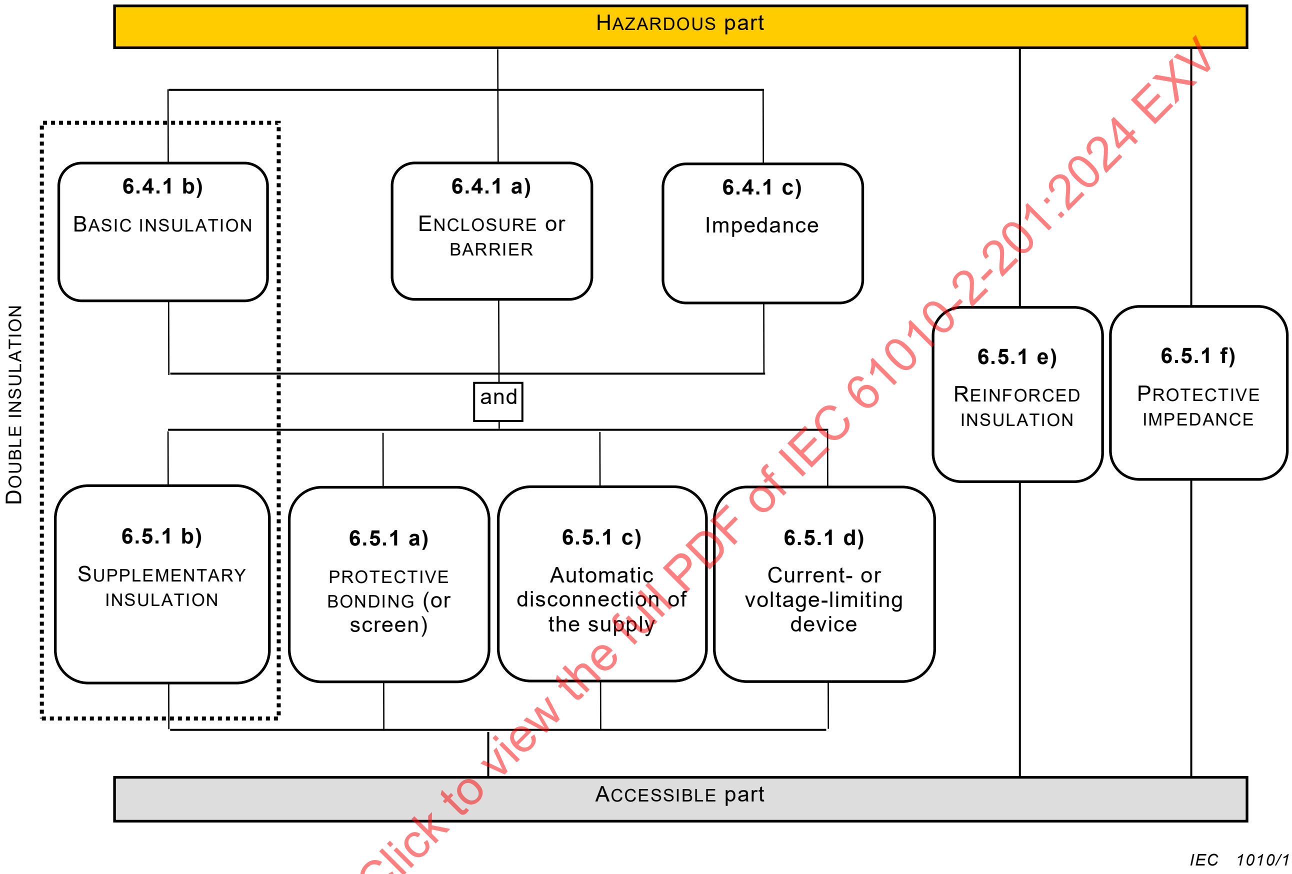


Figure 104 – Acceptable arrangement of protective means against electric shock

6.5.1.101 Classes of equipment or equipment classes

6.5.1.101.1 General

Equipment classes are described to designate the means by which electric shock protection is maintained in NORMAL CONDITION and SINGLE-FAULT CONDITIONS of the equipment.

NOTE Derived from IEC 61140:2016, Clause 7.

6.5.1.101.2 Class I equipment

Class I equipment is equipment in which protection against electric shock is achieved using BASIC INSULATION, and additionally connecting accessible conductive parts to the protective earth conductor.

Class I equipment can have parts with DOUBLE INSULATION or REINFORCED INSULATION or parts operating at safety extra-low voltage.

If a flexible cord is utilized, it shall include a provision for a protective earth conductor that shall be part of the cord set.

ACCESSIBLE conductive parts of equipment, which can become HAZARDOUS LIVE in the event of a single fault, shall be connected to the protective circuit of the equipment. Conductive parts, such as screws, rivets and nameplates, which otherwise could become HAZARDOUS LIVE under single-fault conditions, shall be protected by other means such as DOUBLE/REINFORCED INSULATION so that they do not become HAZARDOUS LIVE.

When a part of the equipment is removed from the ENCLOSURE, for normal maintenance, for example, the protective circuits serving other parts of the equipment shall not be interrupted.

Protective earth requirements are specified in 6.5.2.102 or 6.5.2.103.

6.5.1.101.3 Class II equipment

Class II equipment is equipment in which protection against electric shock does not rely on BASIC INSULATION only, but also on the provision of additional safety precautions, such as DOUBLE INSULATION or REINFORCED INSULATION. There is no provision for protective earth or reliance upon installation conditions.

A PROTECTIVE IMPEDANCE may be used in lieu of DOUBLE or REINFORCED INSULATION.

A means for maintaining the continuity of circuits is acceptable provided that these circuits are double insulated from the ACCESSIBLE circuits of the equipment.

Connection to the earth TERMINALS for functional purposes is acceptable (such as radiofrequency interference suppression) provided the DOUBLE or REINFORCED INSULATION system is still provided for protective purposes.

Equipment shall be of one of the following types:

a) insulation-encased by a durable and substantially continuous ENCLOSURE of insulating material which envelops all conductive parts. Small parts, such as nameplates, screws and rivets are exempted if they are isolated from HAZARDOUS LIVE parts by insulation at least equivalent to REINFORCED INSULATION;
b) metal-encased by a substantially continuous metal ENCLOSURE, in which DOUBLE INSULATION is used throughout, except for those parts where REINFORCED INSULATION is used;
c) combination of a) and b).

NOTE 1 Insulation-encasement can form a part of the whole of the SUPPLEMENTARY INSULATION or of the REINFORCED INSULATION.

NOTE 2 Utilization of DOUBLE INSULATION or REINFORCED INSULATION, or both, throughout, with a PROTECTIVE EARTH TERMINAL or contact, is deemed to be of Class I construction.

NOTE 3 This equipment can have parts operating at safety extra-low voltage.

6.5.1.101.4 Class III equipment

Class III equipment is equipment in which protection against electric shock is provided by circuits supplied by safety extra-low voltage (SELV/PELV). And additionally, the voltages generated by or within the equipment do not exceed the limits for SELV/PELV.

Connection to the earth TERMINALS for functional purposes is acceptable (such as radiofrequency interference suppression).

6.5.2 PROTECTIVE BONDING

6.5.2.1 General

ACCESSIBLE conductive parts shall be bonded to the PROTECTIVE CONDUCTOR TERMINAL if they could become HAZARDOUS LIVE in case of a single fault of the primary means of protection specified in 6.4. Alternatively, such ACCESSIBLE parts shall be separated from parts which are HAZARDOUS LIVE by a conductive protective screen bonded to the PROTECTIVE CONDUCTOR TERMINAL.

NOTE PROTECTIVE EARTH TERMINALS and earth contacts are not connected directly to the neutral TERMINAL within the equipment. This does not prevent the connection of appropriately RATED devices (such as capacitors or surge suppression devices) between the PROTECTIVE EARTH TERMINAL and neutral.

Conformity is checked as specified in 6.5.2.2 to 6.5.2.6.

6.5.2.2 Integrity of PROTECTIVE BONDING

The integrity of PROTECTIVE BONDING shall be assured as specified below.

a) PROTECTIVE BONDING shall consist of directly connected structural parts or discrete conductors, or both. It shall withstand all thermal and dynamic stresses to which it could be subjected before one of the overcurrent protective means specified in 9.6 disconnects the equipment from the supply.

b) Soldered connections subject to mechanical stress shall be mechanically secured independently from the soldering. Such connections shall not be used for other purposes such as fixing constructional parts.

c) Screw connections shall be secured against loosening.

d) If a part of the equipment is removable by an OPERATOR, the PROTECTIVE BONDING for the remainder of the equipment shall not be interrupted (except for a part that also carries the MAINS input connection to the whole equipment).

e) Unless they are specifically designed for electrical inter-connection and meet the requirements of 6.5.2.4, movable conductive connections, for example, hinges, slides, etc., shall not be the sole PROTECTIVE BONDING path.

f) The exterior metal braid of cables shall not be regarded as PROTECTIVE BONDING, even if connected to the PROTECTIVE CONDUCTOR TERMINAL.

g) If power from the MAINS supply is passed through equipment for use by other equipment, means shall also be provided for passing the protective conductor through the equipment to protect the other equipment. The impedance of the protective conductor path through the equipment shall not exceed that specified in 6.5.2.4.

h) Protective conductors may be bare or insulated. Insulation shall be green-and-yellow, except in the following cases:

   1) for earthing braids, either green-and-yellow or colourless-transparent;

   2) for internal protective conductors, and other conductors connected to the PROTECTIVE CONDUCTOR TERMINAL in assemblies such as ribbon cables, busbars, flexible printed wiring, etc., any colour may be used provided that no HAZARD is likely to arise from non-identification of the protective conductor.

NOTE 1 In some countries green colour can be utilized instead of green-and-yellow.

aa) PROTECTIVE BONDING shall not rely on a communication network.

NOTE 2 A communication network, in this context, is a metallically terminated transmission medium intended for communication between equipment that can be located in separate buildings, excluding: the MAINS system for supply, transmission and distribution of electrical power, if used as a communication transmission medium.

Equipment using PROTECTIVE BONDING shall be provided with a TERMINAL that is suitable for connection to a protective conductor and meets the requirements of 6.5.2.3.

Conformity is checked by inspection.

6.5.2.3 PROTECTIVE CONDUCTOR TERMINAL

PROTECTIVE CONDUCTOR TERMINALS shall meet the following requirements.

a) The contact surfaces shall be metal.

NOTE 1 Materials of PROTECTIVE BONDING systems should be chosen to minimize electro-chemical corrosion between the TERMINAL and the protective conductor, or any other metal in contact with them.

b) The integral protective conductor connection of an appliance inlet shall be regarded as the PROTECTIVE CONDUCTOR TERMINAL.

c) For equipment provided with a rewirable flexible cord and for PERMANENTLY CONNECTED EQUIPMENT, the PROTECTIVE CONDUCTOR TERMINAL shall be located near the MAINS supply TERMINALS.

d) If the equipment does not require connection to a MAINS supply, but nevertheless has a circuit or part which is required to be protectively earthed, the PROTECTIVE CONDUCTOR TERMINAL shall be located near the TERMINALS of that circuit for which protective earthing is necessary. If this circuit has external TERMINALS, the PROTECTIVE CONDUCTOR TERMINAL shall also be external.

e) PROTECTIVE CONDUCTOR TERMINALS for MAINS CIRCUITS shall be at least equivalent in current-carrying capacity to the MAINS supply TERMINALS.

f) Plug-in type PROTECTIVE CONDUCTOR TERMINALS combined with other TERMINALS and intended to be connected and disconnected without the use of a TOOL, shall be designed so that the protective conductor connection makes first and breaks last with respect to the other connections. Examples include plugs and appliance couplers for MAINS cords and connector assemblies of plug-in units.

g) If the PROTECTIVE CONDUCTOR TERMINAL is also used for other bonding purposes, the protective conductor shall be applied first and secured independently of other connections. The protective conductor shall be connected in such a way that it is unlikely to be removed during servicing that does not require disconnection of the protective conductor.

h) For equipment in which the protective conductor is required for protection against a single fault in a measuring circuit, the following shall apply:

   1) the PROTECTIVE CONDUCTOR TERMINAL and protective conductor shall have at least the current RATING of the measuring TERMINALS;

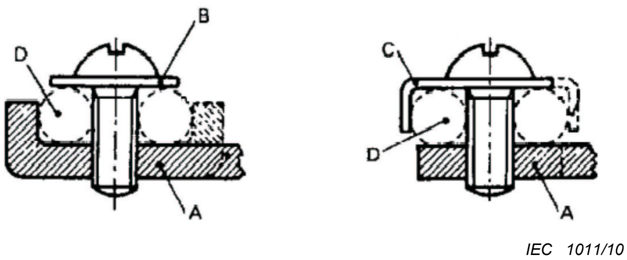
   2) the PROTECTIVE BONDING shall not be interrupted by any switching or interrupting device.

i) FUNCTIONAL EARTH TERMINALS (for example, measuring earth TERMINALS) shall allow a connection which is independent from the connection of the protective conductor.

NOTE 2 Equipment may be equipped with FUNCTIONAL EARTH TERMINALS, irrespective of the protective means taken.

j) If the PROTECTIVE CONDUCTOR TERMINAL is a binding screw assembly (see Figure 5), it shall be of a suitable size for the bond wire, but with a thread size no smaller than 4,0 mm, with at least three turns of the screw engaged.

k) The contact pressure required for a bonding connection shall not be capable of being reduced by deformation of materials forming part of the connection.



Key

A fixed part

B washer or clamping plate

C anti-spread device

D conductor space

Figure 105 – Examples of binding screw assemblies

Conformity is checked by inspection. Conformity for j) is also checked by the following test.

The binding screw assembly is to be tightened and loosened three times, together with the least favourable conductor to be secured, using the tightening torques specified in Table 2. All parts of the binding screw assembly shall withstand this test without mechanical failure.

Table 102 – Tightening torque for binding screw assemblies

Thread size mm	4,0	5,0	6,0	8,0	10,0
Tightening torque N·m	1,2	2,0	3,0	6,0	10,0

6.5.2.4 Impedance of PROTECTIVE BONDING of plug-connected equipment

The impedance between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,1 Ω. If the equipment has a non-detachable power cord, the impedance between the protective conductor plug pin of the MAINS cord and each ACCESSIBLE part for which PROTECTIVE BONDING is specified shall not exceed 0,2 Ω.

Conformity is checked by applying a test current for 1 min and then calculating impedance. The test current is the greater of

a) 25 A a.c. r.m.s. at RATED MAINS frequency or d.c.,

b) a current equal to twice the RATED current of the equipment.

If the equipment contains overcurrent protection devices for all poles of the MAINS supply, and if the wiring on the supply side of the overcurrent protection devices cannot become connected to ACCESSIBLE conductive parts in the case of a single fault, the test current need not be more than twice the RATED current of the internal overcurrent protection devices.

6.5.2.5 Impedance of PROTECTIVE BONDING of PERMANENTLY CONNECTED EQUIPMENT

PROTECTIVE BONDING of PERMANENTLY CONNECTED EQUIPMENT shall be of low impedance.

Conformity is checked by applying a test current of twice the value of the overcurrent protection means specified in the equipment installation instructions for the building supply MAINS CIRCUIT for 1 min between the PROTECTIVE CONDUCTOR TERMINAL and each ACCESSIBLE conductive part for which PROTECTIVE BONDING is required. The voltage between them shall not exceed 10 V a.c. r.m.s. or d.c.

If the equipment contains overcurrent protection devices for all poles of the MAINS supply, and if the wiring on the supply side of the overcurrent protection devices cannot become connected to ACCESSIBLE conductive parts in the case of a single fault, the test current need not be more than twice the RATED current of the internal overcurrent protection devices.

6.5.2.6 Transformer PROTECTIVE BONDING screen

If the transformer is fitted with a screen for PROTECTIVE BONDING purposes that is separated only by BASIC INSULATION from a winding that is connected to a HAZARDOUS LIVE circuit, the screen shall satisfy the requirements of 6.5.2.2 a) and b), and be of low impedance.

If the control equipment has no overcurrent protection means for the winding then the test current shall be twice the RATING of the control equipment overcurrent protection means (e.g. fuse, circuit breaker). This overcurrent protection means may either be integrated into the control equipment or specified in the manual.

Conformity is checked by inspection and by one of the following tests:

a) a test current of twice the value of the overcurrent protection means of the winding is applied for 1 min between the screen and the PROTECTIVE CONDUCTOR TERMINAL. The voltage between them shall not exceed 10 V a.c. r.m.s. or d.c.;

b) the test of 6.5.2.4 using test current twice the value of the overcurrent protection means of the winding. The impedance shall not exceed 0,1 Ω.

NOTE If test a) or b) is carried out, a specially prepared sample transformer having an extra lead-out wire from the free end of the screen is used to ensure that the current during the test passes through the screen.

6.5.2.101 Protective earth requirements for ENCLOSED EQUIPMENT

The ACCESSIBLE parts of Class I equipment (e.g. chassis, frame and fixed metal parts of metal ENCLOSURES) other than those which cannot become HAZARDOUS LIVE shall be electrically interconnected and connected to a PROTECTIVE EARTH TERMINAL.

This requirement can be met by structural parts providing adequate electrical continuity. This applies whether the equipment is used on its own or incorporated in an assembly.

Cords or cables that supply power to Class I equipment PORTABLE EQUIPMENT peripherals shall be provided with a protective earth conductor.

ACCESSIBLE isolated conductive parts are considered not to constitute a danger if they are so located as to exclude any contact with live parts and withstand the dielectric test voltage of Table 5 for REINFORCED INSULATION, corresponding to the highest RATED operational voltage of the unit.

Class II equipment may have an internal functional earth bonding conductor but shall not be provided with a PROTECTIVE EARTH TERMINAL or a protective earth conductor in the equipment power input cord.

If the equipment is provided with a PROTECTIVE EARTH TERMINAL (Class I equipment), the following requirements also apply in addition to the previous general connection specifications.

- The PROTECTIVE EARTH TERMINAL shall be readily ACCESSIBLE and so placed that the connection of the equipment to the protective earth conductor is maintained when the cover or any removable part is removed.
- Products which are intended for MAINS cord connected use (such as equipment peripherals) shall be provided with a PROTECTIVE EARTH TERMINAL integral to the plug cap or socket (if removable cord set).
- The PROTECTIVE EARTH TERMINAL shall be of screw, stud or pressure type and shall be made of a suitable corrosion resistant material.
- The clamping means of PROTECTIVE EARTH TERMINALS shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a TOOL.

- PROTECTIVE EARTH TERMINALS and earth contacts shall not be connected direct to the neutral TERMINAL within the equipment. This does not prevent the connection of appropriately RATED devices (such as capacitors or surge suppression devices) between the PROTECTIVE EARTH TERMINAL and neutral.
- The PROTECTIVE EARTH TERMINAL and subsequent protective equipment internal to the equipment shall comply with the requirements in 6.5.2.4 or 6.5.2.5.
- The PROTECTIVE EARTH TERMINAL shall have no other function.

6.5.2.102 Protective earth requirements for OPEN EQUIPMENT

OPEN EQUIPMENT shall comply with the requirements of 6.5.2.4 or 6.5.2.5 with the exception that the provision for connection to an external protective conductor may be replaced by a means for bonding to the ENCLOSURE ACCESSIBLE to the OPERATOR.

6.5.3 SUPPLEMENTARY INSULATION and REINFORCED INSULATION

CLEARANCES, CREEPAGE DISTANCES and solid insulation forming SUPPLEMENTARY INSULATION or REINFORCED INSULATION shall meet the applicable requirements of 6.7.

Conformity is checked as specified in 6.7.

6.5.4 PROTECTIVE IMPEDANCE

A PROTECTIVE IMPEDANCE shall limit the current or voltage to the levels of 6.3.1 in NORMAL CONDITION and 6.3.2 in SINGLE FAULT CONDITION.

Insulation between the terminations of the PROTECTIVE IMPEDANCE shall meet the requirements of 6.7 for 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 is 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.

A PROTECTIVE IMPEDANCE shall not be a single electronic device that employs electron conduction in a vacuum, gas or semiconductor

Conformity is checked by inspection, by measuring the current or voltage to confirm that they do not exceed the applicable levels of 6.3 and by measuring CLEARANCES and CREEPAGE DISTANCES as specified in 6.7. Conformity of a single component is checked by inspection of its RATINGS.

6.5.5 Automatic disconnection of the supply

An automatic disconnection device shall meet both the following requirements.

a) It shall be RATED to disconnect the load within the time specified in Figure 2.
b) It shall be RATED for the maximum RATED load conditions of the equipment.

Conformity is checked by inspection of the device specification. In case of doubt, the device is tested to check that it disconnects the supply within the required time.

6.5.6 Current- or voltage-limiting device

A current- or voltage-limiting device shall meet all the following requirements:

a) it shall be RATED to limit the current or voltage to the levels not exceeding the values of 6.3.2;
b) it shall be RATED for the maximum WORKING VOLTAGE and, if applicable, for the maximum operational current;
c) CLEARANCE and CREEPAGE DISTANCE between the terminations of the current or voltage-limiting device shall meet the applicable requirements of 6.7 for SUPPLEMENTARY INSULATION.

Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 6.3.2, and by measuring CLEARANCES and CREEPAGE DISTANCES as specified in 6.7.

6.6 Connections to external circuits

6.6.1 General

In NORMAL CONDITION and in SINGLE FAULT CONDITION of the equipment, no ACCESSIBLE parts of the equipment and no ACCESSIBLE parts of an external circuit shall become HAZARDOUS LIVE as a result of connecting the external circuit to the equipment.

NOTE 1 External circuits are all circuits connected to TERMINALS of the equipment.

NOTE 2 For cord connected MAINS supply, see 6.10.

Protection shall be achieved by separation of circuits, unless short-circuiting of the separation could not cause a HAZARD.

The manufacturer's instructions or equipment markings shall include the following information, if applicable, for each external TERMINAL:

a) RATED conditions at which the TERMINAL has been designed to operate while maintaining safety (maximum RATED input/output voltage, specific type of connector, designated use, etc.);
b) RATING of the insulation required for the external circuit to conform to the requirements for protection against electric shock, arising from the connection to the TERMINAL, in NORMAL CONDITION and SINGLE FAULT CONDITION.

Conformity is checked by:

1) *inspection;*
2) *the determinations of 6.2;*
3) *the measurements of 6.3 and 6.7;*
4) *the voltage test of 6.8 (without humidity preconditioning) applicable to the type of insulation (see 6.7).*

6.6.2 TERMINALS for external circuits

An external circuit is a circuit connected by FIELD WIRING of the control equipment.

All parts of TERMINALS that maintain contact and carry current shall be of metal of adequate mechanical strength.

The mechanical design of the interfaces shall allow that no individual conductor is subjected to bending of a radius of curvature less than six times its diameter after removal of the covering elements (armour, sheaths, fillers).

Conformity is checked by inspection.

ACCESSIBLE conductive parts of TERMINALS that receive a charge from an internal capacitor shall not be HAZARDOUS LIVE 10 s after interruption of the supply.

Conformity is checked by inspection, and by the determination of ACCESSIBLE conductive parts as specified in 6.2 and in case of doubt by measurement of the remaining voltage or charge.

6.6.3 Circuits with TERMINALS which are HAZARDOUS LIVE

This subclause applies to both TERMINALS and PORTS (see Table 101).

For ENCLOSED EQUIPMENT no ACCESSIBLE conductive parts may be HAZARDOUS LIVE. For OPEN EQUIPMENT protection for those TERMINALS and PORTS defined in Table 101 shall be provided.

Conformity is checked by inspection.

6.6.4 TERMINALS for stranded conductors

TERMINALS for stranded conductors that are intended to be connected during installation, maintenance, or operation of the equipment shall be located or shielded so that there is no possibility of accidental contact between HAZARDOUS LIVE parts of different polarity or between such parts and other ACCESSIBLE parts, even if a strand of a conductor escapes from a TERMINAL. This requirement does not apply to connections that are only to be made at the manufacturing facility.

Conformity is checked by inspection after fully inserting a stranded conductor

a) with the maximum length of insulation removed as specified by the equipment manufacturer, or

b) with an 8 mm length of insulation removed if no specification is given by the equipment manufacturer.

With one of the strands free, the free strand shall not touch parts of different polarity or other ACCESSIBLE parts, when bent in every possible direction, without tearing back the insulation or making sharp bends.

TERMINALS of circuits carrying HAZARDOUS LIVE voltage or current shall be anchored, fitted or designed so that conductors will not work loose when they are tightened, loosened or when connections are made.

Conformity is checked by manual test and inspection.

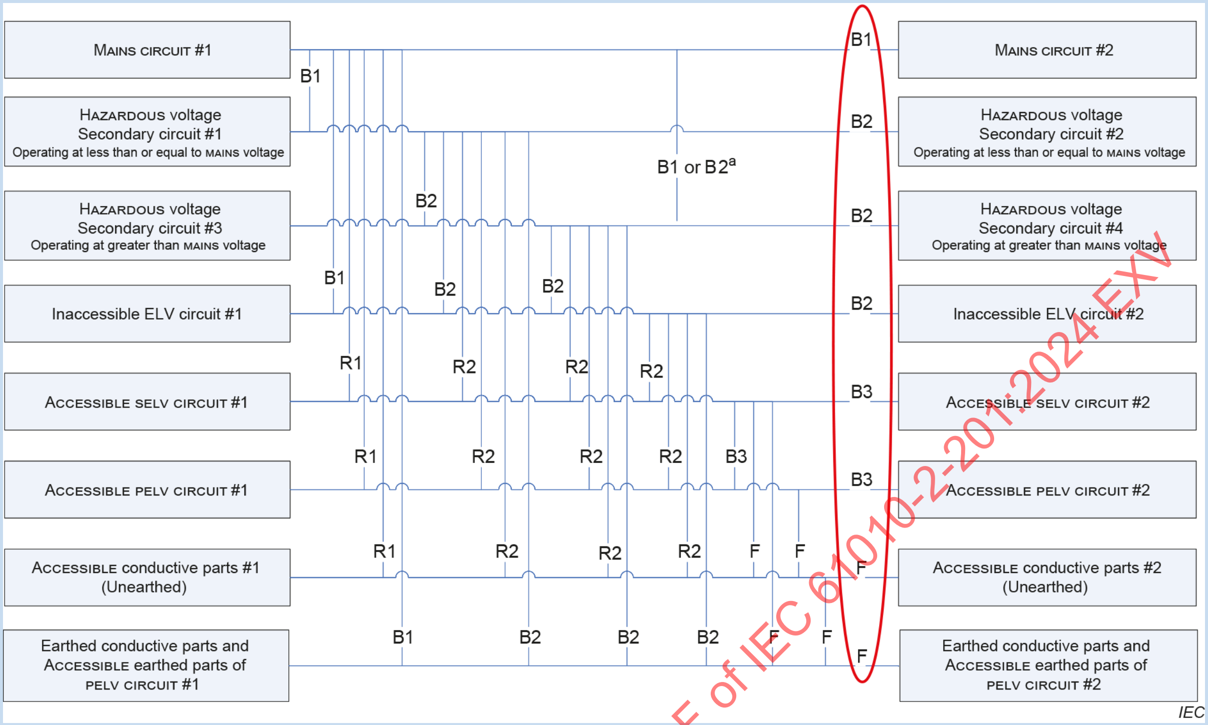
6.7 Insulation requirements

6.7.1 The nature of insulation

6.7.1.1 General

Insulation between circuits and ACCESSIBLE parts (see 6.2) or between separate circuits consists of a combination of CLEARANCES, CREEPAGE DISTANCES and solid insulation. When used to provide protection against a HAZARD, the insulation needs to withstand the electric stresses that are caused by the voltages that may appear on the MAINS supply or in the equipment.

Insulation between separate circuits and between circuits and ACCESSIBLE conductive parts are shown in Figure 102. Figure 102 does not encompass all possibilities, rather it depicts a set of common situations. Further information, particularly in the context of OPEN EQUIPMENT, is given in Annex BB.



a Where both B1 and B2 may apply, the greater requirement shall be applied across the separation.

B1 Separation between circuits shall provide minimum one level of protection, as required in 6.4. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.2, Clause K.1 or Clause K.3.

B2 Separation between circuits shall provide minimum one level of protection, as required in 6.4. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.3, Clause K.2 or Clause K.3.

B3 Separation between circuits shall provide minimum one level of protection. Where distances are required, CREEPAGE, CLEARANCE and solid insulation shall comply with the requirements of 6.7.1.101. Alternatively, the fault test of 4.4.1 may be applied instead of insulation.

R1 Separation between circuits shall provide minimum two levels of protection, as required in 6.4 and 6.5. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.2, Clause K.1 or Clause K.3.

R2 Separation between circuits shall provide minimum two levels of protection, as required in 6.4 and 6.5. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.3, Clause K.2 or Clause K.3.

F Functional insulation. No specific level specified.

Earthed conductive parts – Shall meet the requirements of 6.5.2.4 or 6.5.2.5.

Items circled in red, on the right side, may be applied for protection against HAZARDS other than electrical shock, e.g. protection against the spread of fire (Clause 9) or protection against overtemperature or skin burn (Clause 10).

Where a HAZARDOUS LIVE circuit may be used also as a non-HAZARDOUS LIVE circuit, it shall also be investigated for all applicable insulations, and the greater requirement shall be applied across the separation.

Figure 102 – Examples of insulation between separate circuits and between circuits and ACCESSIBLE conductive parts

Electric stresses originating from MAINS include:

a) WORKING VOLTAGE across the insulation. This WORKING VOLTAGE is normally the line-to-neutral voltage of the MAINS supply (also see Annex I);

b) TRANSIENT OVERVOLTAGES that may occasionally appear on the line conductors. The magnitude of the overvoltages depends on the OVERVOLTAGE CATEGORY and the line-to-neutral voltage of the MAINS supply;

c) short-term TEMPORARY OVERVOLTAGES that may occur between the line conductor and earth in electrical installations. These TEMPORARY OVERVOLTAGES may have a value of the line-to-neutral voltage of the MAINS supply plus 1 200 V, and may last up to 5 s;

d) long-term TEMPORARY OVERVOLTAGES that may occur between the line conductor and earth in electrical installations. These TEMPORARY OVERVOLTAGES may have a value of the line-to neutral voltage of the MAINS supply plus 250 V and may last longer than 5 s.

NOTE See IEC 60364-4-44, Clause 442 for additional information on these TEMPORARY OVERVOLTAGES.

The requirements for insulation depend on:

1) the required level of insulation (BASIC INSULATION, SUPPLEMENTARY INSULATION, or REINFORCED INSULATION);
2) the maximum TRANSIENT OVERVOLTAGE that may appear 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;
3) the maximum WORKING VOLTAGE (including steady-state and recurring peak voltages);
4) the POLLUTION DEGREE of the micro-environment;
5) the maximum TEMPORARY OVERVOLTAGE that may occur in a MAINS CIRCUIT because of a fault in the MAINS distribution system.

Between ACCESSIBLE SELV CIRCUITS, ACCESSIBLE PELV CIRCUITS or ungrounded conductive ACCESSIBLE parts and HAZARDOUS LIVE parts, there shall be two levels of protection: e.g. DOUBLE INSULATION, REINFORCED INSULATION, BASIC INSULATION + PROTECTIVE BONDING.

6.7.1.2 CLEARANCES

Required CLEARANCES depend on the factors in 6.7.1.1 a) to d) as well as the RATED altitude for operation. If the equipment is RATED to operate at an altitude greater than 2 000 m, all CLEARANCES shall be multiplied by the applicable factor of Table 3.

Table 3 – Multiplication factors for CLEARANCES of equipment RATED for operation at altitudes up to 5 000 m

RATED operating altitude m	Factor
Up to 2 000	1,00
3 000	1,14
4 000	1,29
5 000	1,48
NOTE This table is derived from IEC 60664-1:2020, Table A.2.	

Linear interpolation of the altitude factor is permitted between the nearest two points in Table 3. The calculated minimum CLEARANCE using this multiplication factor shall be rounded up to the next higher 0,1 mm increment.

See Annex C for details of how to measure CLEARANCES.

6.7.1.3 CREEPAGE DISTANCES

Required CREEPAGE DISTANCES depend on the factors in 6.7.1.1 a) to d) as well as the Comparative Tracking Index (CTI) of the insulating material.

Materials are separated into four groups according to their CTI values, as follows:

Material group I	600 ≤ CTI
Material group II	400 ≤ CTI < 600
Material group IIIa	175 ≤ CTI < 400
Material group IIIb	100 ≤ CTI < 175

These CTI values refer to values obtained, in accordance with IEC 60112, on samples of the relevant material specifically made for the purpose and tested with solution A. For materials where the CTI value is not known, material group IIIb is assumed.

For glass, ceramics, or other inorganic insulating materials which do not track, there are no requirements for CREEPAGE DISTANCES.

A CREEPAGE DISTANCE may be split in several portions of different materials and/or have different POLLUTION DEGREES if one of the CREEPAGE DISTANCES is dimensioned to withstand the total voltage or if the total distance is dimensioned according to the material having the lowest CTI and the highest POLLUTION DEGREE.

See Annex C for details of how to measure CREEPAGE DISTANCES.

6.7.1.4 Solid insulation

The requirements for solid insulation depend on the factors in 6.7.1.1 a) to d).

The term “solid insulation” is used to describe many different types of construction, including monolithic blocks of insulating material and insulation subsystems composed of multiple insulating materials, organized in layers or otherwise.

The electric strength of a thickness of solid insulation is considerably greater than that of the same thickness of air. The insulating distances through solid insulation are therefore typically smaller than the distances through air. As a result, electric fields in solid insulation are typically higher, and often are less homogeneous.

Solid insulation material may contain gaps or voids. When a solid insulation system is constructed from layers of solid materials, there are also likely to be gaps or voids between layers. These voids will perturb the electric field so that a disproportionately large part of the electric field is located in the void, potentially causing ionization within the void, resulting in partial discharge. These partial discharges will influence the adjacent solid insulation and may reduce its service life.

Solid insulation is not a renewable medium: damage is cumulative over the life of the equipment. Solid insulation is also subject to ageing and to degradation from repeated high voltage testing.

6.7.1.5 Requirements for insulation according to type of circuit

Requirements for insulation between separate circuits and between circuits and ACCESSIBLE conductive parts are specified as follows (where the separation in question fits under more than one item, the most stringent requirement shall be used):

a) in 6.7.2 for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II with a nominal supply voltage up to 300 V;

NOTE 1 See Annex I for nominal voltages of MAINS supplies.

NOTE 2 Subclause 6.7.2 applies for any insulation where at least one side is connected to the MAINS circuit, supplied from a source classified as OVERVOLTAGE CATEGORY II.

EXAMPLE 1 Between MAINS and MAINS, MAINS and secondary, or between MAINS and ACCESSIBLE surfaces.

b) in 6.7.3 for secondary circuits separated from the circuits in a) only by means of a transformer;

NOTE 3 Subclause 6.7.3 applies for insulation between ACCESSIBLE circuits or ACCESSIBLE surfaces and other HAZARDOUS LIVE circuits, where these HAZARDOUS LIVE circuits are not directly connected to MAINS. Such circuits are generally considered as secondary circuits..

c) in Clause K.1 for MAINS CIRCUITS of OVERVOLTAGE CATEGORY III or IV or for OVERVOLTAGE CATEGORY II over 300 V;

d) in Clause K.2 for secondary circuits separated from the circuits in c) only by means of a transformer;

e) in Clause K.3 for circuits that have one or more of the following characteristics:

1) the maximum possible TRANSIENT OVERVOLTAGE is limited by the supply source or within the equipment to a known level below the level assumed for the MAINS CIRCUIT;

2) the maximum possible TRANSIENT OVERVOLTAGE is above the level assumed for the MAINS CIRCUIT;

3) the WORKING VOLTAGE is the sum of voltages from more than one circuit, or is a mixed voltage;

EXAMPLE 2 Between two circuts isolated from each other, such as MAINS and secondary, or between two secondary circuits.

4) the WORKING VOLTAGE includes a recurring peak voltage that may include a periodic non-sinusoidal waveform or a non-sinusoidal waveform that occurs with some regularity;

5) the WORKING VOLTAGE has a frequency above 30 kHz;

NOTE 4 See Clause K.3 for requirements for switching circuits such as a switching power supply.

aa) Separation of SELV/PELV CIRCUITS from each other or SELV CIRCUITS to earth parts are specified in 6.7.1.101.

Requirements for insulation of measuring circuits are specified in IEC 61010-2-030.

6.7.1.101 Separation for SELV/PELV CIRCUITS

Where separation between SELV or PELV CIRCUITS are required for protection against hazard other than electric shock, the separating insulation of SELV/PELV CIRCUITS from each other or for the separating insulation of SELV CIRCUITS to earth parts, the following shall be fulfilled.

The minimum CLEARANCES for SELV/PELV CIRCUITS are:

– for POLLUTION DEGREE 1 = 0,01 mm;
– for POLLUTION DEGREE 2 = 0,2 mm;
– for POLLUTION DEGREE 2 = 0,04 mm for printed wiring board material;
– for POLLUTION DEGREE 3 = 0,8 mm.

NOTE CLEARANCE adjustment for altitude is not necessary as corrections are negligible.

Solid insulation shall pass the voltage test of 6.8 using the test voltage of 300 V a.c. for 1 min.

For SELV/PELV CIRCUITS the CREEPAGE distances from Table 7 shall be applied.

6.7.2 Insulation for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II with a nominal supply voltage up to 300 V

6.7.2.1 CLEARANCES and CREEPAGE DISTANCES

CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS shall meet the values of Table 4 taking the following into account.

a) The values in Table 4 are for BASIC INSULATION and SUPPLEMENTARY INSULATION. Values for REINFORCED INSULATION shall be twice the values for BASIC INSULATION.

b) Minimum CLEARANCE for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION for POLLUTION DEGREE 3 is 0,8 mm.

c) If the equipment is RATED to operate at an altitude greater than 2 000 m, the CLEARANCES shall be multiplied by the applicable factor of Table 3.

Conformity is checked by inspection and measurement.

Since conformity is checked by inspection and measurement, the dielectric test is not required.

Table 4 – CLEARANCE and CREEPAGE DISTANCES for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II up to 300 V

Voltage line-to-neutral a.c. RMS V [c]	Values for CLEARANCE distances[d]			Values for CREEPAGE DISTANCES[b]								
	POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 3	POLLUTION DEGREE 1		POLLUTION DEGREE 2				POLLUTION DEGREE 3		
				PWB MG I, II, III	MG I, II, III	PWB MG I,II,IIIa	MG I	MG II	MG III	MG I	MG II	MG III
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
≤ 50	0,04	0,2[a]	0,8	0,04	0,18	0,04	0,6	0,85	1,2	1,5	1,7	1,9
≤ 100	0,1	0,2[a]	0,8	0,1	0,25	0,16	0,71	1,0	1,4	1,8	2,0	2,2
≤ 150	0,5	0,5	0,8	0,5	0,5	0,5	0,8	1,1	1,6	2,0	2,2	2,5
≤ 300	1,5	1,5	1,5	1,5	1,5	1,5	1,5	2,1	3	3,8	4,2	4,7

NOTE 1 This table is derived from IEC 60664-1:2020, Table F.1, Table F.2 and Table F.5.

NOTE 2 MG I = Material group I, CTI ≥ 600.

NOTE 3 MG II = Material group II, 600 > CTI ≥ 400.

NOTE 4 MG III = MG IIIa and MG IIIb.

NOTE 5 MG IIIa = Material group IIIa, 400 > CTI ≥ 175.

NOTE 6 MG IIIb = Material group IIIb, 175 > CTI ≥ 100.

NOTE 7 PWB = Printed wiring board.

NOTE 8 CREEPAGE values calculated for this table have been increased so they are not below CLEARANCE values. See footnote [b] below.

[a] For printed wiring board, the values for POLLUTION DEGREE 1 apply.

[b] Linear interpolation of CREEPAGE is allowed but CREEPAGE can never be below CLEARANCE.

[c] d.c. or a.c. peak values are √2 × a.c. RMS values shown.

[d] Interpolation for CLEARANCES is not permitted.

Linear interpolation of the CREEPAGE DISTANCES is allowed.

Coatings that meet the requirements of Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

Conformity of coatings is checked as specified in Annex H.

NOTE See Annex FF for examples of CLEARANCES and CREEPAGE measurement special cases.

6.7.2.2 Solid insulation

6.7.2.2.1 General

If MAINS or secondary voltage is greater than 300 V, refer to Annex K.

Solid insulation of MAINS CIRCUITS shall withstand the electric and mechanical stresses that may occur in NORMAL USE, in all RATED environmental conditions (see 1.4), during the intended life of the equipment.

NOTE The manufacturer should take the expected life of the equipment into account when selecting insulating materials.

Conformity is checked by inspection, and by the a.c. test of 6.8.3.1 or the d.c. test of 6.8.3.2, using the applicable voltage from Table 5 for 1 min.

Table 5 – Test voltages for solid insulation between MAINS and between MAINS and secondary circuits OVERVOLTAGE CATEGORY II up to 300 V

Voltage line-to-neutral a.c. RMS V [a]	For BASIC INSULATION and SUPPLEMENTARY INSULATION				For REINFORCED INSULATION			
	Test voltages V				Test voltages V			
	a.c.		d.c.		a.c.		d.c.	
	5 s	1 min	5 s	1 min	5 s	1 min	5 s	1 min
≤ 50[b]	1 250	300	1 750	420	2 500	600	3 500	850
≤ 100[c]	1 300	350	1 800	500	2 600	700	3 600	990
≤ 150	1 350	400	1 900	570	2 700	800	3 800	1 100
≤ 300	1 500	550	2 100	780	3 000	1 100	4 200	1 600

NOTE This table is derived from IEC 60664-1:2020, 5.4.3.2.

[a] d.c. or a.c. peak values are √2 × a.c. RMS values shown.

[b] For d.c. products this range ends at 60 V.

[c] For d.c. products this range begins at 60 V.

Solid insulation shall also meet the following requirements, as applicable:

a) for solid insulation used as an ENCLOSURE or PROTECTIVE BARRIER, the requirements of Clause 8;
b) for moulded and potted parts, the requirements of 6.7.2.2.2;
c) for inner layers of printed wiring boards, the requirements of 6.7.2.2.3;
d) for thin-film insulation, the requirements of 6.7.2.2.4.

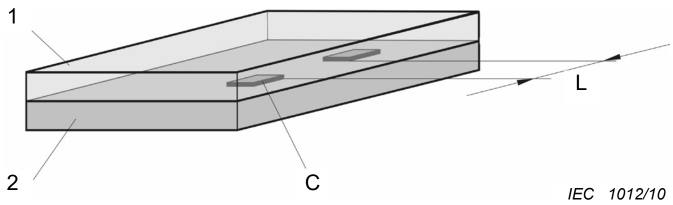
Conformity is checked by inspection, and by the a.c. test of 6.8.3.1, or the d.c. test of 6.8.3.2, using the applicable voltage from Table 5. Both the 1 min and 5 s test shall be performed or a single test which is the worst case combination of the 1 min and 5 s tests.

NOTE 101 For example, if a 1 min test with 1,1 kV and a 5 s test with 3 kV are required, instead a single test with 3 kV and 1 min is sufficient.

6.7.2.2.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located on an interface between the same two layers moulded together shall be separated by at least 0,4 mm (see Figure 6, item L) after the moulding is completed.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key

1 Layer 1

2 Layer 2

C Conductor

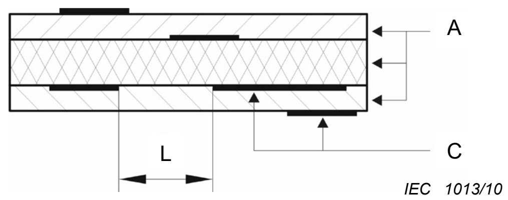
L Distance between conductors

Figure 6 – Distance between conductors on an interface between two layers

6.7.2.2.3 Inner insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers shall be separated by at least 0,4 mm (see Figure 7, item L).

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key

L Distance between adjacent conductors

A Layers

C Conductors

Figure 7 – Distance between adjacent conductors along an interface of two inner layers

REINFORCED INSULATION of inner insulating layers of printed wiring boards shall also have adequate electric strength through the respective layers. One of the following methods shall be used:

a) the thickness of the insulation is at least 0,4 mm;

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of Table 5 for BASIC INSULATION;

Conformity is checked by inspection of the manufacturer's specifications.

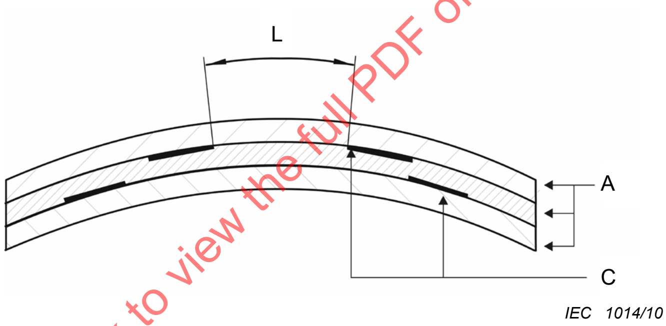
c) the insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of Table 5 for REINFORCED INSULATION.

Conformity is checked by inspection of the manufacturer's specifications.

6.7.2.2.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure 8, item L).shall be separated by the applicable CLEARANCE and CREEPAGE DISTANCE of 6.7.2.1.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key

L Distance between adjacent conductors

A Layers of thin-film material such as tape and polyester film

C Conductors

NOTE There may be air present between the layers

Figure 8 – Distance between adjacent conductors located between the same two layers

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used:

a) the thickness through the insulation is at least 0,4 mm;

Conformity is checked by inspection and either by measurement of the part or by inspection of the manufacturer's specifications.

b) the insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of Table 5 for BASIC INSULATION;

Conformity is checked by inspection of the manufacturer's specifications.

c) the insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

Conformity is checked by the a.c. test of 6.8.3.1 or the d.c. test of 6.8.3.2 applied to two of the three layers using the applicable voltage for REINFORCED INSULATION of Table 5 for 1 min.

NOTE For the purposes of this test a special sample may be assembled with only two layers of the material.

6.7.3 Insulation for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY II up to 300 V

6.7.3.1 General

In this standard, secondary circuits are circuits where separation from MAINS CIRCUITS is achieved by a transformer in which the primary windings are separated from the secondary windings by REINFORCED INSULATION, DOUBLE INSULATION, or a screen connected to the PROTECTIVE CONDUCTOR TERMINAL. For MAINS CIRCUITS above 300 V, see Annex K. For additional information on secondary circuits, see Annex CC.

NOTE These circuits are assumed to be subjected to lower TRANSIENT OVERVOLTAGE levels than the MAINS CIRCUIT.

6.7.3.2 CLEARANCES

CLEARANCES for secondary circuits shall meet a) or b):

a) for BASIC INSULATION and SUPPLEMENTARY INSULATION, meet the values of Table 6, or for REINFORCED INSULATION meet twice the values of Table 6;
b) pass the voltage test of 6.8 using the applicable test voltage from Table 6.

The following adjustments apply:

1) values for test voltages for REINFORCED INSULATION are 1,6 times the values for BASIC INSULATION;
2) if the equipment is RATED to operate at an altitude greater than 2 000 m, the values for CLEARANCES are multiplied by the applicable factor of Table 3;
3) minimum CLEARANCE is 0,2 mm for POLLUTION DEGREE 2 and 0,8 mm for POLLUTION DEGREE 3.

Conformity is checked by inspection and measurement and for b) by the a.c. test of 6.8.3.1 with a duration of at least 5 s, or by the 1 min d.c. test of 6.8.3.2, using the applicable test voltage from Table 6. The value of the d.c. test voltage is √2 times the a.c. r.m.s. test voltage.

Table 6 – CLEARANCES and test voltages for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY II up to 300 V

	MAINS voltage, OVERVOLTAGE CATEGORY II					
	≤ 100 V a.c. RMS [b]		≤ 150 V a.c. RMS [b]		≤ 300 V a.c. RMS [b]	
	RATED impulse voltage 500 V		RATED impulse voltage 800 V		RATED impulse voltage 1 500 V	
Secondary WORKING VOLTAGE V a.c. RMS [b]	CLEARANCE mm [a]	Test voltage V a.c. RMS	CLEARANCE mm [a]	Test voltage V a.c. RMS	CLEARANCE mm [a]	Test voltage V a.c. RMS
10	0,04	440	0,10	500	0,47	770
12,5	0,04	440	0,10	500	0,47	770
16	0,04	440	0,10	500	0,48	830
30	0,05	455	0,11	510	0,50	840
50	0,05	455	0,12	520	0,53	860
100	0,07	476	0,13	540	0,61	900
150	0,10	507	0,16	580	0,69	940
300	0,24	641	0,39	770	0,94	1 040
600	0,79	980	1,01	1 070	1,61	1 450
1 000	1,66	1 500	1,92	1 630	2,52	1 970
1 250	2,23	1 700	2,50	1 960	3,16	2 280
1 600	3,08	2 200	3,39	2 390	4,11	2 730
2 000	4,17	2 750	4,49	2 890	5,30	3 230
2 500	5,64	3 300	6,02	3 520	6,91	3 850
3 200	7,98	4 000	8,37	4 390	9,16	4 660
4 000	10,6	4 900	10,9	5 320	11,6	5 610
5 000	13,7	6 000	14,0	6 590	14,9	6 960
6 300	17,8	8 000	18,2	8 270	19,1	8 620
8 000	23,5	10 000	23,9	10 400	24,7	10 700
10 000	30,3	12 500	30,7	12 900	31,6	13 300
12 500	39,1	15 800	39,6	16 100	40,5	16 400
16 000	52,0	20 000	52,5	20 400	53,5	20 700
20 000	67,4	25 000	67,9	25 300	68,9	25 600
25 000	87,4	31 300	87,9	31 600	89,0	32 000
32 000	117	40 400	117	40 400	118	40 700
40 000	151	50 300	151	50 300	153	50 800
50 000	196	62 800	196	62 800	198	63 400
63 000	258	79 400	258	79 400	260	80 000

[a] Linear interpolation allowed.

[b] d.c. or a.c. peak values are √2 × a.c. RMS values shown.

6.7.3.3 CREEPAGE DISTANCES

CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION for secondary circuits shall meet the applicable values of Table 7, based on the WORKING VOLTAGE which stresses the insulation. Values for REINFORCED INSULATION are twice the values for BASIC INSULATION.

Conformity is checked by inspection and measurement.

Coatings that meet the requirements of Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

Conformity of coatings is checked as specified in Annex H.

Table 7 – CREEPAGE DISTANCES for secondary circuits

Secondary WORKING VOLTAGE a.c. RMS	Printed wiring board material		Other insulating material						
	POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 1	POLLUTION DEGREE 2			POLLUTION DEGREE 3		
	All material groups	Material groups I, II or IIIa	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III[b]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,40	0,40	0,40	1,00	1,00	1,00
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,10	0,45	0,45	0,45	1,10	1,10	1,10
20	0,025	0,04	0,11	0,48	0,48	0,48	1,20	1,20	1,20
25	0,025	0,04	0,125	0,50	0,50	0,50	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,80	1,10	1,4	1,6	1,8
50	0,025	0,04	0,18	0,60	0,85	1,20	1,5	1,7	1,9
63	0,040	0,063	0,20	0,63	0,90	1,25	1,6	1,8	2,0
80	0,063	0,10	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,10	0,16	0,25	0,71	1,00	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,40	0,32	0,80	1,1	1,6	2,0	2,2	2,5
200	0,40	0,63	0,42	1,00	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,60	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9,0	10,0
800	2,4	4,0	2,4	4,0	5,6	8,0	10,0	11	12,5
1 000	3,2 [a]	5,0 [a]	3,2	5,0	7,1	10,0	12,5	14	16
1 250			4,2	6,3	9,0	12,5	16	18	20
1 600			5,6	8,0	11	16	20	22	25
2 000			7,5	10,0	14	20	25	28	32
2 500			10,0	12,5	18	25	32	36	40
3 200			12,5	16	22	32	40	45	50
4 000			16	20	28	40	50	56	63
5 000			20	25	36	50	63	71	80
6 300			25	32	45	63	80	90	100
8 000			32	40	56	80	100	110	125
10 000			40	50	71	100	125	140	160
12 500			50	63	90	125			
16 000			63	80	110	160			
20 000			80	100	140	200			
25 000			100	125	180	250			
32 000			125	160	220	320			
40 000			160	200	280	400			
50 000			200	250	360	500			
63 000			250	320	450	600			

[a] For voltages above 1 000 V, CREEPAGE DISTANCES on printed wiring board material are the same as for other insulators of the same Material Group.

[b] Material group IIIb is not recommended for application in POLLUTION DEGREE 3 above 630 V.

Linear interpolation is allowed.

6.7.3.4 Solid insulation

6.7.3.4.1 General

Solid insulation in secondary circuits shall withstand the electrical and mechanical stresses that may occur in NORMAL USE, in all RATED environmental conditions (see 1.4), during the intended life of the equipment.

NOTE The manufacturer should take the expected life of the equipment into account when selecting insulating materials.

Conformity is checked by both of the following tests:

a) *by the voltage test of 6.8.3.1 for 5 s using the applicable test voltage of Table 6 for BASIC INSULATION or SUPPLEMENTARY INSULATION. For REINFORCED INSULATION the values are multiplied by 1,6;*
b) *additionally, if the WORKING VOLTAGE exceeds 300 V, by the voltage test of 6.8.3.1 for 1 min with a test voltage of 1,5 times the WORKING VOLTAGE for BASIC INSULATION or SUPPLEMENTARY INSULATION and twice the WORKING VOLTAGE* for *REINFORCED INSULATION.*

Solid insulation shall also meet the following requirements, as applicable:

1) for solid insulation used as an ENCLOSURE or PROTECTIVE BARRIER, the requirements of Clause 8;
2) for moulded and potted parts, the requirements of 6.7.3.4.2;
3) for inner insulating layers of printed wiring boards, the requirements of 6.7.3.4.3;
4) for thin-film insulation, the requirements of 6.7.3.4.4.

Conformity is checked as specified in 6.7.3.4.2 to 6.7.3.4.4 and Clause 8, as applicable.

6.7.3.4.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers shall be separated by the applicable minimum distance of Table 8 (see Figure 6 item L).

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

Table 8 – Minimum values for distance or thickness (see 6.7.3.4.2 to 6.7.3.4.4)

Peak value of the a.c. or d.c. WORKING VOLTAGE or recurring peak voltage	Minimum value	Peak value of the a.c. or d.c. WORKING VOLTAGE or recurring peak voltage	Minimum value
kV	mm	kV	mm
>0,046 7 ≤ 0,33	0,05	>8,0 ≤ 10	3,5
>0,33 ≤ 0,8	0,1	>10 ≤ 12	4,5
>0,8 ≤ 1,0	0,15	>12 ≤15	5,5
>1,0 ≤ 1,2	0,2	>15 ≤ 20	8
>1,2 ≤ 1,5	0,3	>20 ≤ 25	10
>1,5 ≤ 2,0	0,45	>25 ≤ 30	12,5
>2,0 ≤ 2,5	0,6	>30 ≤ 40	17
>2,5 ≤ 3,0	0,8	>40 ≤ 50	22
>3,0 ≤ 4,0	1,2	>50 ≤ 60	27
>4,0 ≤ 5,0	1,5	>60 ≤ 80	35
>5,0 ≤ 6,0	2	>80 ≤ 100	45
>6,0 ≤ 8,0	3		

6.7.3.4.3 Inner insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers shall be separated by the applicable minimum distance of Table 8 (see Figure 7, item L).

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

REINFORCED INSULATION of inner insulating layers of printed wiring boards shall also have adequate electric strength through the respective layers. One of the following methods shall be used:

a) the thickness of the insulation is at least the applicable minimum distance of Table 8;

   Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength at least the value of the test voltage of Table 6 for BASIC INSULATION;

   Conformity is checked by inspection of the manufacturer's specifications.

c) the insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength at least the value of the test voltage of Table 6 multiplied by 1,6.

   Conformity is checked by inspection of the manufacturer's specifications.

6.7.3.4.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure 8, item L) shall be separated by at least the applicable CLEARANCE and CREEPAGE DISTANCE of 6.7.3.2 and 6.7.3.3.

Conformity is checked by measurement or by inspection of the part or the manufacturer's specifications.

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used:

a) the thickness of the insulation is at least the applicable value of Table 8;

   Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of Table 6 for BASIC INSULATION;

   Conformity is checked by inspection of the manufacturer's specifications.

c) the insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

   Conformity is checked by the a.c. test of 6.8.3.1 with a duration of at least 1 min, or, for circuits stressed only by d.c., the 1 min d.c. test of 6.8.3.2, using the applicable test voltage from Table 6 multiplied by 1,6, applied to two of the three layers.

   NOTE For the purposes of this test a special sample may be assembled with only two layers of the material.

6.8 Procedure for voltage tests

6.8.1 General

The following test procedures apply to type testing, and deterioration of the test specimen may occur. Further use of the test specimen may not be appropriate.

Test equipment for the voltage tests is specified in IEC 61180-1 and IEC 61180-2.

ACCESSIBLE insulating parts of the ENCLOSURE are covered with metal foil everywhere except around TERMINALS. For test voltages up to 10 kV a.c. peak or d.c., the distance from foil to TERMINAL is not more than 20 mm. For higher voltages it is the minimum to prevent flashover. For guidance to these minimum distances, see Table 9.

NOTE The distances of Table 9 will prevent flashover between foil and TERMINALS.

Table 9 – Distances between TERMINALS and foil

Test voltage	Distance
kV	mm
10	20
20	45
30	70
50	130
70	195
100	290

ACCESSIBLE parts of controls with parts made of insulating material are wrapped in metal foil or have soft conductive material pressed against them.

The foil is applied after the humidity preconditioning (if applicable) and connected to the low TERMINAL of the test voltage generator.

When verifying a CLEARANCE within equipment, it is necessary to ensure that the specified voltage appears at the CLEARANCE. PROTECTIVE IMPEDANCE, impedances and voltage-limiting devices in parallel with the insulation to be tested may be disconnected.

The equipment is not energized during the tests.

When verifying CLEARANCES, the values for test voltages given in 6.7 apply to tests performed at 2 000 m. For other test site altitudes, the corrections of Table 10 are applied for CLEARANCES but not for tests of solid insulation.

NOTE 1 The electric testing of CLEARANCES will also stress the associated solid insulation.

NOTE 2 Where two or more protective means are used in combination (see 6.5.1), the voltages specified for REINFORCED INSULATION might be applied to parts of circuits which are not required to withstand these voltages. To test the complete equipment appropriately it may be necessary to test subassemblies separately.

Table 10 – Correction factors according to test site altitude for test voltages for CLEARANCES

	Correction factors			
Test voltage peak	**≥327 V < 600 V**	**≥600 V < 3 500 V**	**≥3 500 V < 25 kV**	**≥25 kV**
Test voltage r.m.s.	**≥231 V < 424 V**	**≥424 V < 2 475 V**	**≥2 475 V < 17,7 kV**	**≥17,7 kV**
Test site altitude m				
0	1,08	1,16	1,22	1,24
500	1,06	1,12	1,16	1,17
1 000	1,04	1,08	1,11	1,12
2 000	1,00	1,00	1,00	1,00
3 000	0,96	0,92	0,89	0,88
4 000	0,92	0,85	0,80	0,79
5 000	0,88	0,78	0,71	0,70
Linear interpolation is allowed.				

6.8.2 Humidity preconditioning

Unless otherwise specified in this standard, the equipment is subjected to humidity preconditioning before the voltage tests. The equipment is not energized during preconditioning.

This treatment need not be applied to parts that are clearly unlikely to be influenced by humidity and temperature.

Parts which can be removed without the use of a TOOL are removed and subjected to humidity preconditioning together with the main part.

Preconditioning is carried out in a humidity chamber containing air with a humidity of 93 % RH ± 3 % RH. The temperature of the air in the chamber is maintained at 40 °C ± 2 °C.

Before applying humidity, the equipment is brought to a temperature of 42 °C ± 2 °C, normally by keeping it at this temperature for at least 4 h before the humidity preconditioning.

The air in the chamber is stirred and the chamber is designed so that condensation will not precipitate on the equipment.

The equipment remains in the chamber for 48 h, after which it is removed and allowed a recovery period of 2 h under the environmental conditions of 4.3.1, with the covers of non-ventilated equipment removed.

The tests are performed and completed within 1 h of the end of the recovery period after humidity preconditioning. Parts that have been removed are re-assembled or not, whichever is less favourable.

6.8.3 Test procedures

6.8.3.1 The a.c. voltage test

The voltage tester shall be capable of maintaining the test voltage throughout the test within ±5 % of the specified value.

The voltage tester shall have a regulated output capable of maintaining the test voltage throughout the test. The waveform of the test voltage shall be substantially sinusoidal. This requirement is fulfilled if the ratio between the peak value and the r.m.s. value is √2 ± 3 %.

The a.c. voltage test is performed at the RATED MAINS frequency, but for equipment RATED for MAINS frequencies including 50 Hz and 60 Hz, a test at either 50 Hz or at 60 Hz is sufficient.

The test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least the specified time.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.

6.8.3.2 The d.c. voltage test

The voltage tester shall be capable of maintaining the test voltage throughout the test within ±5 % of the specified value.

The d.c. test voltage shall be substantially free of ripple. This requirement is fulfilled if the ratio between the peak value of the voltage and the average value is 1,0 ± 3 %.

The d.c. test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least the specified time.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.

6.8.3.3 The impulse voltage test

The test shall be conducted for five impulses of each polarity with an interval of at least 1 s between impulses. The impulse voltage test is carried out with a 1,2/50 μs waveform (see Figure 1 of IEC 61180-1). The wave shape of each impulse shall be observed (see Note 1).

When verifying CLEARANCES within equipment by an impulse voltage test, it is necessary to ensure that the specified impulse voltage appears at the CLEARANCE. PROTECTIVE IMPEDANCE and voltage-limiting devices in parallel with the insulation to be tested shall be disconnected.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, but partial discharges are allowed. Partial discharge will be indicated by a step in the resulting wave shape which will occur earlier in successive impulses. Breakdown on the first impulse may either indicate a complete failure of the insulation system or the operation of overvoltage limiting devices in the equipment.

NOTE 1 If there are overvoltage limiting devices in the equipment, care must be taken to examine the waveshape to ensure that their operation is not taken to indicate insulation failure. Distortions of the impulse voltage which do *not change from impulse to impulse may be caused by operation of an overvoltage limiting device and do not indicate a (partial) breakdown of solid insulation.*

NOTE 2 Partial discharges in voids can lead to partial notches of extremely short durations in the waveform which may be repeated in the course of an impulse.

6.9 Constructional requirements for protection against electric shock

6.9.1 General

If a failure could cause a HAZARD:

a) the security of wiring connections subject to mechanical stresses shall not depend on soldering;

b) screws securing removable covers shall be captive if their length determines a CLEARANCE or CREEPAGE DISTANCE between ACCESSIBLE conductive parts and HAZARDOUS LIVE parts;

c) accidental loosening or freeing of the wiring, screws, etc., shall not cause ACCESSIBLE parts to become HAZARDOUS LIVE;

d) CLEARANCES and CREEPAGE DISTANCES between the ENCLOSURE and HAZARDOUS LIVE parts shall not be reduced below the values for BASIC INSULATION by loosening of parts or wires.

NOTE Screws or nuts with lock washers are not regarded as likely to become loose, nor are wires which are mechanically secured by more than soldering alone.

Conformity is checked by inspection and by measurement of CLEARANCES and CREEPAGE DISTANCES.

6.9.2 Insulating materials

The following shall not be used as insulation for safety purposes:

a) materials which can easily be damaged (for example, lacquer, enamel, oxides, anodic films);

b) non-impregnated hygroscopic materials (for example, paper, fibres, fibrous materials).

Conformity is checked by inspection.

6.9.3 Colour coding

Green-and-yellow insulation shall not be used except for:

a) protective earth conductors;

b) PROTECTIVE BONDING conductors;

c) potential equalization conductors for safety purposes;

d) functional earth conductors.

NOTE In some countries green colour can be utilized instead of green-and-yellow.

Conformity is checked by inspection.

6.9.101 Wiring for SELV/PELV CIRCUITS

Wiring for SELV/PELV CIRCUITS shall be either separated from the wiring of non-SELV/PELV CIRCUITS, or the insulation of all conductors shall be RATED for the higher voltage.

Alternatively, earthed screening or additional separation shall be provided for SELV/PELV CIRCUITS or around the wiring of non-SELV/PELV CIRCUITS.

6.10 Connection to the MAINS supply source and connections between parts of equipment

IEC 61010-1:2010, Subclause 6.10 is only applicable to cord connected MAINS supply.

6.10.1 MAINS supply cords

The following requirements apply to non-detachable MAINS supply cords and to detachable MAINS supply cords supplied with the equipment.

Cords shall be RATED for the maximum current for the equipment and the cable used shall meet the requirements of IEC 60227 or IEC 60245. Cords certified or approved by a recognized testing authority are regarded as meeting this requirement.

If a cord is likely to contact hot external parts of the equipment, it shall be made of suitably heat-resistant material.

If the cord is detachable, both the cord and the appliance inlet shall have adequate temperature RATINGS.

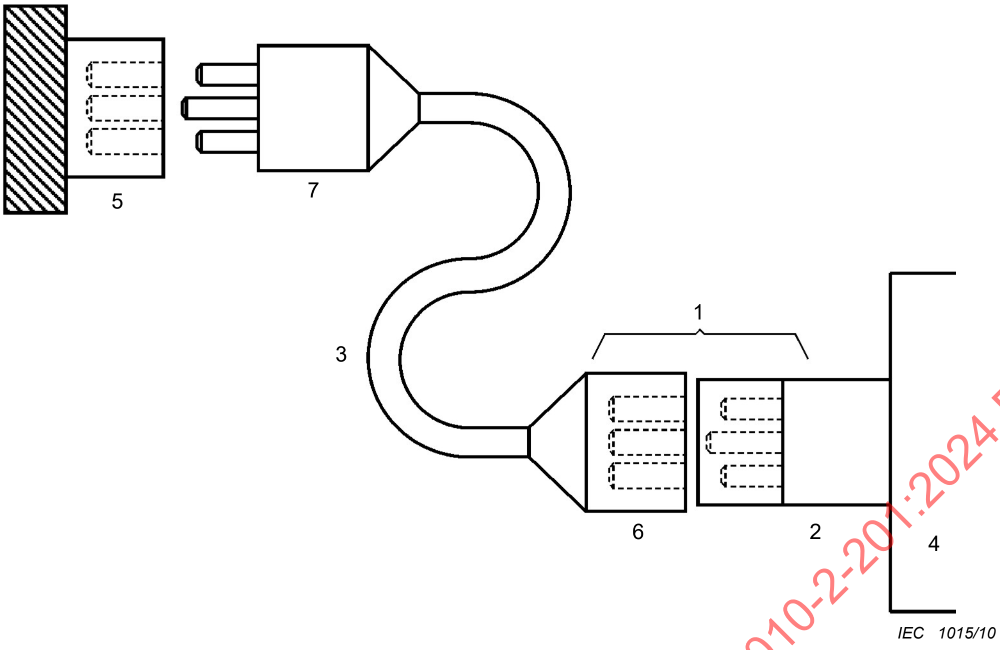
Conductors coloured green-and–yellow shall be used only for connection to PROTECTIVE CONDUCTOR TERMINALS.

NOTE In some countries green colour can be utilized instead of green-and-yellow.

Detachable MAINS supply cords with MAINS connectors according to IEC 60320 shall either meet the requirements of IEC 60799, or shall be RATED at least for the current RATING of the MAINS connector fitted to the cord.

Figure 9 explains the terminology for MAINS supply cords.

Conformity is checked by inspection and, where necessary, by measurement.



Key

1	Appliance coupler	5	Fixed mains socket-outlet
2	Appliance inlet	6	Mains connector
3	Cable	7	Mains plug
4	Equipment		

Figure 9 – Detachable MAINS supply cords and connections

6.10.2 Fitting of non-detachable MAINS supply cords

6.10.2.1 Cord entry

MAINS supply cords shall be protected against abrasion and sharp bends at the point where the cord enters the equipment, by one of the following means:

a) an inlet or bushing with a smoothly rounded opening;

b) a reliably fixed flexible cord guard made of insulating material protruding beyond the inlet opening by at least five times the overall diameter of a cord with the largest cross-sectional area which can be fitted. For flat cords, the larger cross-sectional dimension is taken as the overall diameter.

Conformity is by inspection, and if needed by measurement of dimensions.

6.10.2.2 Cord anchorage

The cord anchorage shall relieve the conductors of the cord from strain, including twisting, where they are connected within the equipment, and shall protect the insulation of the conductors from abrasion. The protective earth conductor, if any, shall be the last to take the strain if the cord slips in its anchorage.

Cord anchorages shall meet the following requirements:

a) the cord shall not be clamped by a screw which bears directly on the cord;

b) knots in the cord shall not be used;

c) it shall not be possible to push the cord into the equipment to an extent which could cause a HAZARD;

d) failure of the cord insulation in a cord anchorage which has metal parts shall not cause ACCESSIBLE conductive parts to become HAZARDOUS LIVE.

e) it shall not be possible to loosen the cord anchorage without the use of a TOOL.

f) it shall be designed so that cord replacement does not cause a HAZARD, and it shall be clear how the relief from strain is provided.

A compression bushing shall not be used as a cord anchorage unless it is suitable for use with the MAINS supply cord supplied with it or specified for it by the manufacturer.

Conformity is checked by inspection and by the following push-pull test:

For each combination of cord and bushing, the cord is pushed into the equipment manually, as far as possible. It is then subjected 25 times to a steady pull of the value shown in Table 11, applied for 1 s each time in the least favourable direction. Immediately afterwards it is subjected for 1 min to a torque of the value shown in Table 11. The torque shall be applied as close as possible to the external end of the cord anchorage or bushing.

Table 11 – Values for physical tests on cord anchorages

Mass of equipment kg	Force for pull test N	Torque for torque test N·m
≤1	30	0,10
>1 ≤ 4	60	0,25
>4	100	0,35

After the tests:

1) *the cord shall not have been damaged;*
2) *the cord shall not have been displaced longitudinally by more than 2 mm;*
3) *there shall be no signs of strain at the point where the anchorage clamps the cord;*
4) *CLEARANCES and CREEPAGE DISTANCES shall not have been reduced below the applicable values;*
5) *the cord shall pass the a.c. voltage test of 6.8.3.1 (without humidity preconditioning) with a duration of at least 1 min as follows:*
   i) *for equipment with a protective earth conductor, the test is made between the protective conductor and the line and neutral conductors joined together, with the test voltage from Table 5 or Table K.8 for BASIC INSULATION for the appropriate line-to-neutral voltage;*
   ii) *for equipment without a protective earth conductor, the test is made between ACCESSIBLE conductive parts of the equipment and the line and neutral conductors joined together, with the test voltage from Table 5 or Table K.8 for REINFORCED INSULATION for the appropriate line-to-neutral voltage.*

6.10.3 Plugs and connectors

Plugs and connectors for connecting equipment to the MAINS supply, including appliance couplers used to connect detachable MAINS supply cords, shall conform to the relevant specifications for plugs, socket-outlets and connectors.

If the equipment is designed to be supplied only at voltages below the level of 6.3.2 a) in NORMAL CONDITION or SINGLE FAULT CONDITION, or from a source used solely to supply that equipment, the plugs of the power supply cord shall not fit into the socket-outlets of MAINS supply systems at voltages above the RATED supply voltage of the equipment. MAINS-type plugs and sockets shall not be used for purposes other than connection of a MAINS supply.

If plug pins of cord-connected equipment receive a charge from an internal capacitor, the pins shall not be HAZARDOUS LIVE 5 s after disconnection of the supply.

On equipment with accessory MAINS socket-outlets:

a) if the outlet can accept a standard MAINS supply plug, there shall be a marking as specified in 5.1.3 e);
b) if the outlet has a TERMINAL contact for a protective earth conductor, the input MAINS supply connection to the equipment shall include a protective earth conductor connected to a PROTECTIVE CONDUCTOR TERMINAL.

Conformity is checked by inspection. For plugs receiving a charge from an internal capacitor, the measurements of 6.3 are made to establish that the levels of 6.3.1 c) are not exceeded.

6.11 Disconnection from supply source

IEC 61010-1:2010, Subclause 6.11 is not applicable.

NOTE IEC 61010-1:2010, Subclause 6.11 is not used for this document. Local practices and codes govern the aspect of installation and use of control equipment.

7 Protection against mechanical HAZARDS

7.1 General

The equipment shall not cause a mechanical HAZARD in NORMAL USE, or cause a HAZARD in a SINGLE-FAULT CONDITION that might not be easily noticed. Mechanical HAZARDS include, but are not limited to, the following:

a) sharp edges which could cause cuts (see 7.2);
b) moving parts that could crush body parts or penetrate the skin (see 7.3);
c) unstable equipment that could fall on a person while in use or while being moved (see 7.4);
d) falling equipment, resulting from breakage of the carrying device (see 7.5), wall mounting bracket (see 7.6) or other support part (see 7.5); and
e) expelled parts from the equipment (see 7.7).

NOTE If the equipment consists of two or more units, the value of the mass refers to the mass of each individual unit. However, if one or more units are intended to be attached to and supported by another unit, these units are treated as a single unit.

Conformity is checked as specified in 7.2 to 7.7.

7.1.101 OPEN and PANEL MOUNTED EQUIPMENT

OPEN EQUIPMENT is intended to be installed within an ENCLOSURE which protects the OPERATOR from HAZARDS, including mechanical HAZARDS. PANEL MOUNTED EQUIPMENT may be considered as OPEN EQUIPMENT for the portion that is inside the ENCLOSURE, however, the portion of the control equipment that is not inside the ENCLOSURE and is otherwise ACCESSIBLE to an OPERATOR shall be considered to form part of an ENCLOSURE providing protection against potential HAZARDS and shall be evaluated in accordance with Clause 7.

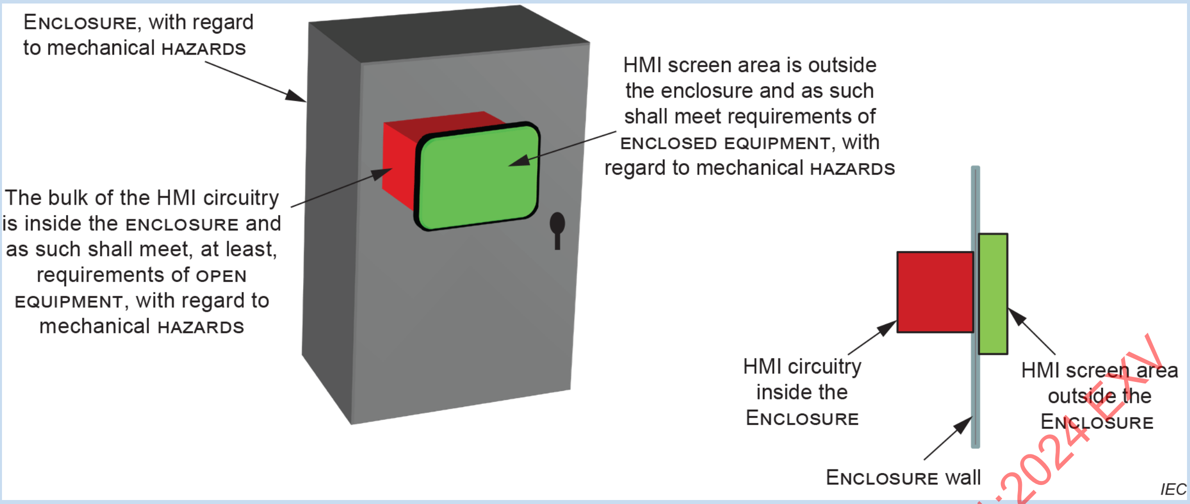


Figure 103 – Mechanical HAZARDS, with regard to PANEL MOUNTED EQUIPMENT

7.2 Sharp edges

All easily-touched parts of the equipment shall be smooth and rounded so as not to cause injury during NORMAL USE of the equipment.

Unless the fault presents an obvious HAZARD, easily-touched parts of the equipment shall not cause an injury in SINGLE FAULT CONDITION.

Consideration may be given to parts or areas uniquely accessible to service personnel.

Conformity 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 or cuts.

NOTE An acceptable procedure is outlined in UL 1439.

7.3 Moving parts

7.3.1 General

HAZARDS from moving parts shall not exceed a tolerable level except as specified in 7.3.2. The conditions specified in 7.3.4 and 7.3.5 are considered to represent a tolerable level. If these conditions are not met, a RISK assessment shall be carried out according to 7.3.3 or Clause 17.

NOTE In this context moving parts mean parts that are driven by an energy source other than directly applied human or animal effort.

Conformity is checked as specified in 7.3.2, 7.3.3, 7.3.4, 7.3.5 and Clause 17 as applicable.

7.3.2 Exceptions

If it is not feasible for operating reasons to prevent certain moving parts from causing a potential HAZARD, access is permitted in the following circumstances.

a) Equipment with easily-touched moving parts which are obviously intended to operate on parts or materials external to the equipment, for example drilling and mixing equipment, shall be designed to minimize inadvertent touching of these moving parts (for example, by guards or handles).

b) If, during routine maintenance outside NORMAL USE, it is unavoidable for technical reasons for an OPERATOR to perform a function which requires access to moving parts that could cause a HAZARD, access is permitted if all of the following precautions have been taken:

1) access is not possible without the use of a TOOL;
2) the instructions for the RESPONSIBLE BODY include a statement that OPERATORS must be trained before being allowed to perform the hazardous operation;
3) there are warning markings on covers or parts which have to be removed to obtain access, prohibiting access by untrained OPERATORS. As an alternative, symbol 14 of Table 1 shall be placed on the covers or parts, with the warnings included in the documentation.

Conformity is checked by inspection.

7.3.3 RISK assessment for mechanical HAZARDS to body parts

RISKS shall be reduced to a tolerable level by at least the applicable minimum protective measure of Table 12, taking into account the severity, probability of exposure and possibility of avoiding the HAZARD.

If a control equipment has only cooling fans as moving parts, then only a check for accessibility is necessary.

Conformity is checked by evaluation of the RISK assessment documentation to ensure that the RISKS have been eliminated or that only TOLERABLE RISKS remain.

Table 12 – Protective measures against mechanical HAZARDS to body parts

Mechanical HAZARD conditions			Minimum protective measures [d]
Severity [a]	Probability of exposure [b]	Possibility of avoiding the HAZARD [c]	
S	E_2	P_2	C
S	E_2	P_1	C
S	E_1	P_2	C
S	E_1	P_1	B
M	E_2	P_2	B
M	E_2	P_1	A
M	E_1	P_2	A
M	E_1	P_1	No action

[a] **Severity:**

M = Moderate HAZARDS, sufficient to bruise or scratch a body part.

S = Serious HAZARDS, sufficient to break bones or dismember a body part.

[b] **Probability of exposure:**

E_1 = Exposure is not intended during NORMAL USE

E_2 = Exposure is intended during NORMAL USE

[c] **Possibility of avoiding the HAZARD:**

P_1 = Possibility of avoidance:

– The motion is visible and velocity is low enough for body parts to be removed without being trapped, or

– an audible or visible alarm is activated before body parts can be trapped.

P_2 = No possibility of avoidance:

Conditions other than P1.

[d] **Minimum protective measures:**

A = Low level measures; warning markings, audible or visual signals or instructions for use.

B = Moderate measures; emergency switches, PROTECTIVE BARRIERS or covers removable only with a TOOL, distances (see ISO 13857), or separations (see ISO 13854 or EN 349).

C = Stringent measures; interlocks, PROTECTIVE BARRIERS or covers removable only with a TOOL and with instructions to disconnect from the power source.

7.3.4 Limitation of force and pressure

IEC 61010-1:2010, Subclause 7.3.4 is not applicable.

7.3.5 Gap limitations between moving parts

IEC 61010-1:2010, Subclause 7.3.5 is not applicable.

7.4 Stability

Equipment and assemblies of equipment not secured to the building structure before operation shall be physically stable.

If means are provided to ensure that stability is maintained after the opening of drawers, etc. by an OPERATOR, either these means shall be automatic or there shall be a warning marking to apply the means.

Each castor and support foot shall be RATED to support a load not less than its normal load, or the castors and support feet shall be tested according to d) or e), below.

Conformity is checked by inspection and by carrying out each of the following tests, if applicable, to ensure that the equipment will not overbalance. Containers contain the RATED amount of substance which provides the least favourable conditions of NORMAL USE. Castors are in their least favourable position of NORMAL USE. Doors, drawers, etc. are closed unless otherwise specified below.

a) *Equipment other than HAND-HELD EQUIPMENT is tilted in each direction to an angle of 10° from its normal position.*
b) *Equipment which has both a height of 1 m or more and a mass of 25 kg or more, and all floor-standing equipment, has a force applied at its top, or at a height of 2 m if the equipment has a height of more than 2 m. The force is 250 N, or 20 % of the weight of the equipment, whichever is less, and is applied to all surfaces in directions which could cause the equipment to topple. Stabilizers used in NORMAL USE, and doors, drawers, etc., intended to be opened by an OPERATOR, are in their least favourable positions.*
c) *Floor-standing equipment has a force of 800 N applied downwards at the point of maximum moment to:*
   1) *all horizontal working surfaces;*
   2) *other surfaces providing an obvious ledge and which are not more than 1 m above floor level.*

   Doors, drawers, etc. are closed, except that those intended to be opened by an OPERATOR are in their least favourable positions.
d) *The castor or support foot that supports the greatest load (M) is loaded with 4 times that load (4M).*
e) *The castor or support foot that supports the greatest load is removed from the equipment and the equipment is placed on a flat surface.*

   NOTE During this test, the unit should be secured so that complete overturning is not possible if this could present a HAZARD to those conducting the test. However, this restraint must not interfere with the determination of whether the unit would overbalance.

7.5 Provisions for lifting and carrying

7.5.1 General

Equipment or parts having a mass of 18 kg or more shall be provided with a means for lifting and carrying, or directions shall be given in the documentation.

Conformity is checked as specified in 7.5.2 and 7.5.3.

7.5.2 Handles and grips

If carrying handles or grips are fitted to the equipment, or supplied with it, they shall be capable of withstanding a force of four times the weight of the equipment.

Conformity is checked by inspection and by the following test.

A single handle or grip is subjected to a force corresponding to four times the weight of the equipment. Unless the handle mounting screws (if any) are secured against loosening, one screw is removed before performing these tests. The force is applied uniformly over a 70 mm width at the centre of the handle or grip, without clamping. The force is steadily increased so that the test value is attained after 10 s and maintained for a period of 1 min.

If more than one handle or grip is fitted, the force is distributed between the handles or grips in the same proportion as in NORMAL USE. If the equipment is fitted with more than one handle *or grip but is so designed that it may readily be carried by only one handle or grip, the total force is applied to each handle or grip.*

After the tests the handles or grips shall not have broken loose from the equipment and there shall not be any permanent distortion, cracking or other evidence of failure which could cause a HAZARD.

7.5.3 Lifting devices and supporting parts

Parts of lifting devices and parts that support heavy loads shall be RATED for the maximum load or shall be tested to withstand four times the maximum static load.

Conformity is checked by inspection of the RATINGS of the parts, or by the following test:

A total load equal to four times the maximum load is placed at the least favourable position of a RATED load in NORMAL USE.

During the test, no part of a lifting device or a load support shall break or deform to an extent that could cause a HAZARD.

7.6 Wall mounting

Mounting brackets on equipment intended to be mounted on a wall or ceiling shall withstand a force of four times the weight of the equipment.

Conformity is checked after mounting the equipment in accordance with the manufacturer's instructions, using the fasteners and wall construction specified. Adjustable brackets are adjusted to the position that will give the maximum projection from the wall.

If no wall construction is specified, a 12 mm ± 2 mm thick plasterboard (drywall) on nominal 50 mm × 100 mm ± 10 mm studs at 400 mm ± 10 mm centres is used as the support surface. Fasteners are applied as specified in the installation documentation or, if not specified, are positioned in the plasterboard between the studs.

The mounting brackets are then subjected to a weight equal to four times the weight of the equipment, acting vertically through the centre of gravity. The test weight is applied gradually and is increased from zero to full load in 5 s to 10 s, then maintained for 1 min.

If more than one fastener is specified for mounting a bracket, then one fastener is removed and the test is repeated with a weight equal to two times the weight of the equipment.

After the tests, there shall be no damage to the bracket or the mounting surface which could cause a HAZARD.

7.7 Expelled parts

IEC 61010-1:2010, Subclause 7.7 is not applicable.

8 Resistance to mechanical stresses

8.1 General

Equipment shall not cause a HAZARD when subjected to mechanical stresses likely to occur in NORMAL USE.

The normal energy protection level is 6,8 J with a tolerance of ±5 %.

The normal energy protection level required is 5 J. Levels below 5 J but not less than 1 J are permitted provided that all the following criteria are met:

a) the lower level is justified by a RISK assessment carried out by the manufacturer (see Clause 17);
b) when the equipment is installed in its intended application it cannot easily be touched by unauthorized persons or the general public;
c) in NORMAL USE, the equipment is only accessed for occasional operations such as adjustment, programming or maintenance;
d) the equipment is marked with an IK code in accordance with IEC 62262 or with symbol 14 of Table 1, and the RATED energy level and test method are stated in the accompanying documentation. For non-metallic ENCLOSURES with a minimum RATED ambient temperature below 2 °C, the stated value shall be that applicable to the lowest RATED ambient temperature. If impact energies used are between IK values of IEC 62262, any IK marking shall be for the nearest lower value.

Conformity is checked by inspection and by performing each of the following tests on the ENCLOSURE as applicable:

1) the static test of 8.2.1;
2) for equipment other than HAND-HELD EQUIPMENT and DIRECT PLUG-IN EQUIPMENT, the impact test of 8.2.2 at the energy level specified above. If the specified energy level is not 5 J the test of IEC 62262 is an alternative to the impact test of 8.2.2, using test Eha (pendulum test) or test Ehc (vertical hammer) described in IEC 60068-2-75;
3) except for FIXED EQUIPMENT and equipment with a mass over 100 kg, the test of 8.3.1 or 8.3.2, as applicable. The equipment is not operated during the tests.

An ENCLOSURE with an impact RATING of at least IK08 by the ENCLOSURE manufacturer, and that would clearly have met the criteria of 8.1 i) to 8.1 vii) after that test, need not be subjected to the test of 8.2.2.

Parts which do not form part of an ENCLOSURE are not subjected to the tests of 8.2.1 and 8.2.2.

After the tests, visibly damaged windows and displays shall be inspected to check that HAZARDOUS LIVE parts exceeding the values of 6.3.2 have not become ACCESSIBLE, and insulation of all other parts of the ENCLOSURE which could have been affected by the tests shall pass the voltage tests of 6.8 (without humidity preconditioning) applicable to the type of insulation (see 6.7). In addition the equipment is inspected to check that:

i) *there have been no leaks of corrosive or harmful substances;*
ii) *ENCLOSURES show no cracks which could cause a HAZARD;*
iii) *CLEARANCES are not less than their permitted values;*
iv) *the insulation of internal wiring remains undamaged;*
v) *PROTECTIVE BARRIERS necessary for safety have not been damaged or loosened;*
vi) *no moving parts are exposed, except as permitted by 7.3;*
vii) *there has been no damage which could cause spread of fire.*

8.1.101 OPEN EQUIPMENT

OPEN EQUIPMENT is equipment or components, intended to be installed within an END SYSTEM, WHERE THE OPERATOR is protected against exposure to HAZARDS.

NOTE An end system can be a panel or a installation rack in a restricted access location.

8.1.102 PANEL MOUNTED EQUIPMENT

PANEL MOUNTED EQUIPMENT may be considered as OPEN EQUIPMENT for the portion that is inside the ENCLOSURE, however, the portion of the control equipment that is not inside the ENCLOSURE and is otherwise ACCESSIBLE to an OPERATOR shall be considered to form part of an ENCLOSURE providing protection against potential HAZARDS and shall be evaluated in accordance with Clause 8.

8.2 ENCLOSURE rigidity tests

8.2.1 Static test

The equipment is held firmly against a rigid support and subjected to a force of 30 N applied by the hemispherical end of a hard rod of 12 mm diameter. The rod is applied to each part of the ENCLOSURE which could easily be touched when the equipment is ready for use, including any part of the bottom of PORTABLE EQUIPMENT, and which could cause a HAZARD if distorted.

In case of doubt whether a non-metallic ENCLOSURE will pass this test at an elevated temperature, this test is performed after the equipment is operated at an ambient temperature of 40 °C, or the maximum RATED ambient temperature if higher, until a steady-state condition is reached. The equipment is disconnected from the supply source before the test is performed.

8.2.2 Impact test

Bases, covers, etc., intended to be removed and replaced by an OPERATOR have their fixing screws tightened using a torque likely to be applied in NORMAL USE. With the equipment held firmly against a rigid support, the impact is applied to any point on surfaces which are easily touched in NORMAL USE and which would be likely to cause a HAZARD if damaged.

NOTE A support is considered to be sufficiently rigid if its displacement is less than or equal to 0,1 mm under the effect of an impact directly applied and whose energy corresponds to the degree of protection.

Non-metallic ENCLOSURES of equipment with a minimum RATED ambient temperature below 2 °C are cooled to the minimum RATED ambient temperature, then tested within 10 min.

Impacts may be applied to empty ENCLOSURES if it is clear that the equipment would have passed the test if it had been tested in complete condition.

If an ENCLOSURE is damaged by an impact but meets the pass criteria, a new ENCLOSURE may be used for the next impact.

Each test point is subjected to one impact by a smooth steel sphere with a diameter of approximately 50 mm.

The impact test can be performed with the equipment mounted at 90° to its normal position to allow both the method of Figure 10 a) and Figure 10 b).

Figure 10 a) shows the impact applied to a horizontal surface, with the sphere allowed to fall freely from a height of X.

Figure 10 b) shows the impact applied to a vertical surface, with the sphere suspended by a cord and allowed to fall as a pendulum through a vertical distance of X.

The dimension X and mass are determined by the following equation: $J = X \times m \times g$

J = 6,8 J *with a tolerance of* ±5 %

$g = 10\ m/s^2$

NOTE 1 Values of the dimension *X* and mass are approximately 1,3 m and 0,5 kg using this formula.

NOTE 2 Test formula, units, etc. are derived from the pendulum test method of IEC 60068-2-75.

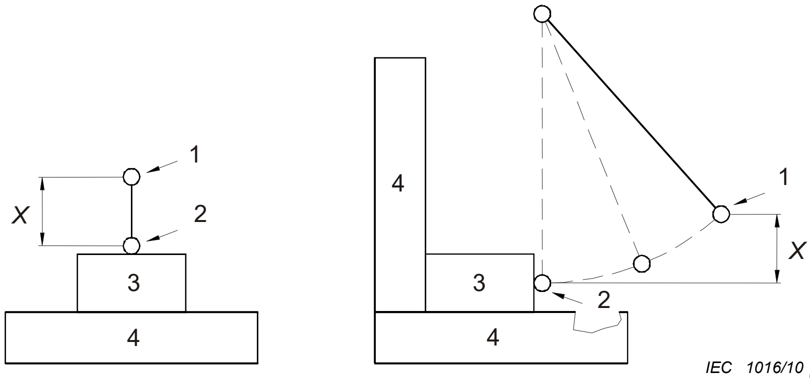


Figure 10a – Impact applied to a horizontal surface

Figure 10b – Impact applied to a vertical surface

Key

1 Sphere start position

2 Sphere impact position

3 Test sample

4 Rigid supporting surface

X Vertical fall distance. See Table 15 for values of *X*

Figure 10 – Impact test using a sphere

Table 15 – Impact energy levels, test height and corresponding IK codes

	Impact energy level J and IK Code		
	1 (IK06)	**2 (IK07)**	**5 (IK08)**
Vertical fall distance (X) mm	200	400	1 000

8.2.2.101 GLASS DISPLAYS

8.2.2.101.1 Glass display impact test

These requirements are applicable to glass displays which can cause a laceration hazard if the glass breaks and falls onto the operator.

Glass that is ACCESSIBLE:

– having a surface area exceeding 0,1 m^2; or

– having a major dimension exceeding 450 mm; or

– that prevents access to a HAZARD,

shall be subjected to the impact test of 8.2.2, Figure 10a,

with the exception of parts made of glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken.

NOTE Laminated glass includes constructions such as plastic film affixed to a single side of a glass.

EXAMPLE HMI display.

Conformity is checked by 8.1 and as follows:

The glass shall:

- *not break or crack; or*
- *not expel pieces of glass greater than 30 g in mass or greater than 50 mm in any dimension; or*
- *pass the glass display fragmentation test of 8.2.2.101.2 on a separate glass display test sample.*

8.2.2.101.2 GLASS DISPLAY fragmentation test

The glass display test sample is shattered with the impact test of 8.2.2, except the ball is dropped vertically onto the display surface.

Conformity is checked by 8.1 and as follows:

The impact shall be applied in a location representing the centre of the surface.

The test sample is supported per installation instructions, placed in a horizontal position, and precautions shall be taken to ensure that particles will not be scattered upon fragmentation. Without using any aid to vision, except spectacles if normally worn, the particles are counted in a square of 50 mm side located approximately at the centre of the area of coarsest fracture and excluding any area within 15 mm of any edge or hole.

The test sample shall fragment in such a way that the number of particles counted in a square with sides of 50 mm shall not be less than 45.

8.3 Drop test

8.3.1 Equipment other than HAND-HELD EQUIPMENT and DIRECT PLUG-IN EQUIPMENT

The equipment is placed in its position of NORMAL USE on a smooth, hard rigid surface of concrete or steel. It is then tilted about each bottom edge in turn so that the distance between the opposite edge and the test surface is 100 mm for equipment up to 20 kg, 25 mm for equipment between 20 kg and 100 kg, or so that the angle made by the bottom and test surface is 30°, whichever is less severe. It is then allowed to fall freely onto the test surface.

If the number of bottom edges exceeds four, the number of drops shall be limited to four edges.

NOTE *If the equipment consists of two or more units, the value for the mass refers to the mass of each individual unit. However, if one or more units are intended to be attached to, or supported by, another unit, these units are treated as a single unit.*

The method of test shall not allow the equipment to topple onto any other face instead of falling back onto the test face as intended.

8.3.2 HAND-HELD EQUIPMENT and DIRECT PLUG-IN EQUIPMENT

The equipment is dropped once through a distance of 1 m onto a 50 mm thick hardwood board having a density of more than 700 kg/m^3 lying flat on a rigid base such as concrete. The equipment is dropped so that it lands in the position expected to present the most severe condition.

Non-metallic ENCLOSURES of equipment with a minimum RATED ambient temperature below 2 °C are cooled to the minimum RATED ambient temperature, then tested within 10 min.

9 Protection against the spread of fire

9.1 General

There shall be no spread of fire outside the equipment in NORMAL CONDITION or in SINGLE FAULT CONDITION. Figure 11 is a flow chart showing methods of conformity verification.

Equipment energized from a MAINS supply shall also meet the requirements of 9.6.

Conformity is checked by at least one of the following methods.

a) *Testing in the SINGLE FAULT CONDITIONS (see 4.4) that could cause the spread of fire outside the equipment. The conformity criteria of 4.4.4.3 shall be met.*

b) *Verifying elimination or reduction of the sources of ignition within the equipment as specified in 9.2.*

c) *Verifying, as specified in 9.3, that if a fire occurs it will be contained within the equipment.*

These alternative methods can be applied throughout the equipment or individually for different sources of HAZARDS or for different areas of the equipment.

NOTE 1 Methods b) and c) are based on fulfilling specified design criteria, in contrast to method a) which relies entirely on testing in specified SINGLE FAULT CONDITIONS.

NOTE 2 See 13.2.2 concerning protection against fire caused by batteries.

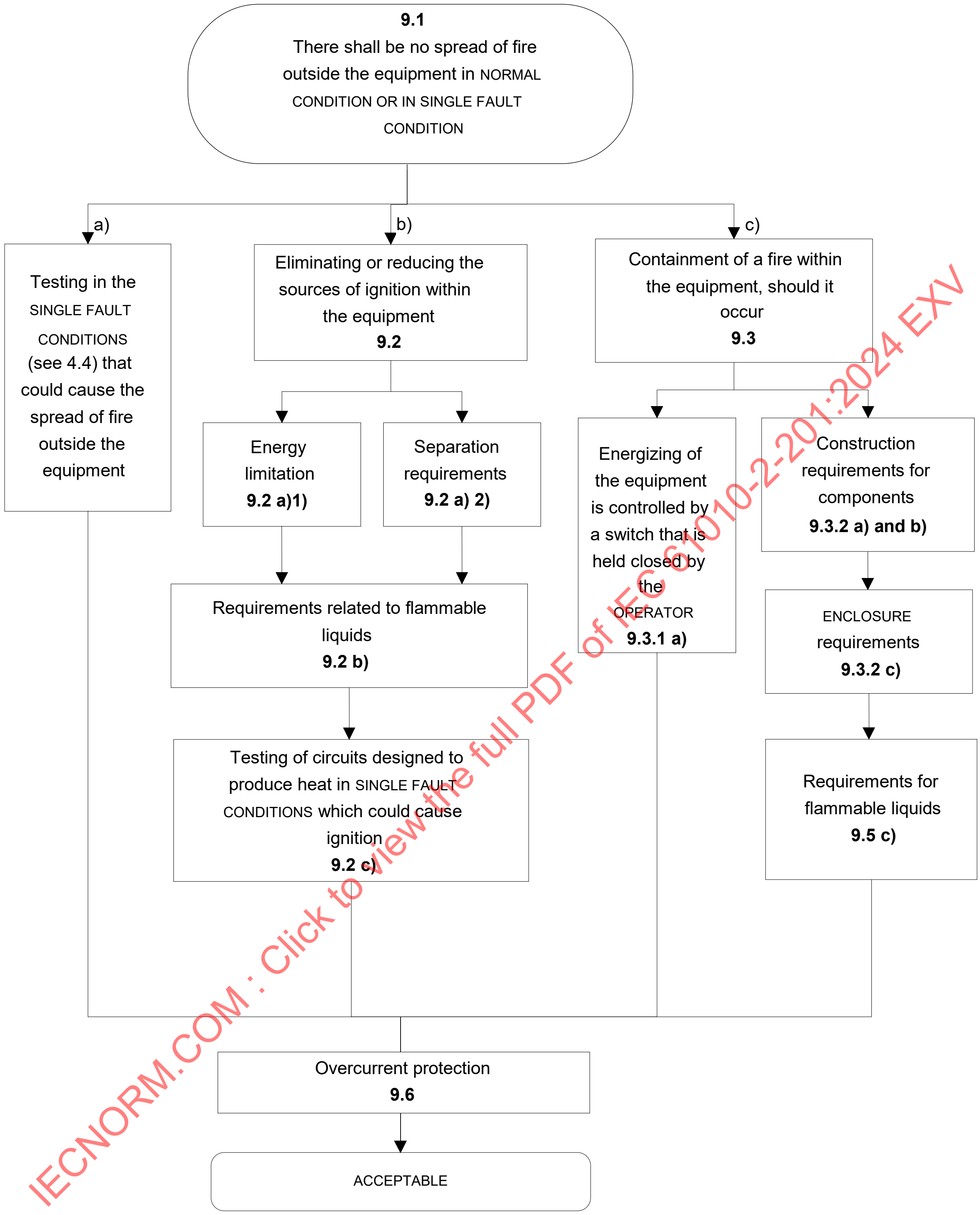


Figure 11 – Flow chart to explain the requirements for protection against the spread of fire

9.2 Eliminating or reducing the sources of ignition within the equipment

The possibility of ignition and occurrence of fire is considered to be reduced to a tolerable level if all the following requirements a), b) and c), if applicable, are met.

a) Either 1) or 2):

1) the voltage, current and power available to the circuit or part of equipment are limited as specified in 9.4;

NOTE Insulation within an energy limited circuit is considered to be functional insulation.

Conformity is checked by measurement of limited-energy values as specified in 9.4.

2) insulation between parts at different potentials meets the requirements for BASIC INSULATION, or it can be demonstrated that bridging the insulation will not cause ignition.

See also Figure 102.

Conformity is checked by inspection and in case of doubt by test.

b) Any ignition HAZARD related to flammable liquids is reduced to a tolerable level as specified in 9.5.

Conformity is checked as specified in 9.5.

c) In circuits designed to produce heat, no ignition occurs when tested in SINGLE FAULT CONDITION (see 4.4).

Conformity is checked by the relevant tests of 4.4, applying the criteria of 4.4.4.3.

9.3 Containment of fire within the equipment, should it occur

9.3.1 General

The possibility of the spread of fire outside the equipment is considered to be reduced to a tolerable level if the equipment meets one of the following constructional requirements:

a) energizing of the equipment is controlled by a switch that needs to be continuously held in the energized state by the OPERATOR;

b) the equipment and the equipment ENCLOSURE conform to the constructional requirements of 9.3.2 and the applicable requirements of 9.5 are met.

Conformity is checked by inspection and as specified in 9.3.2 and 9.5.

9.3.2 Constructional requirements

Application of the requirement for prevention of spread of fire shall take into consideration the type of equipment and where it is intended to be used.

– For ENCLOSED EQUIPMENT, a), b) and c) apply.

– For OPEN EQUIPMENT, a) and b) apply.

For OPEN EQUIPMENT, where the end use location ENCLOSURE provides the protective means to comply with the requirements of c), the installation documentation shall specify the necessary constructional requirements applicable for the end use location, for example acceptable ventilation openings, as required.

NOTE 1 End use location ENCLOSURE can be a rack or panel.

– For PANEL MOUNTED EQUIPMENT, THE PORTION OF THE EQUIPMENT that forms a part of the end location ENCLOSURE, shall comply with a), b), c)1), c)3) and d).

NOTE 2 For PANEL MOUNTED EQUIPMENT the requirements of d) replace those of c)2).

For the portion of the equipment inside the ENCLOSURE, it shall be assessed as either ENCLOSED EQUIPMENT or OPEN EQUIPMENT, and a), b), c) and d) shall be applied accordingly. See also Figure 104.

EXAMPLE A panel mounted HMI device extending through the wall of an end location ENCLOSURE.

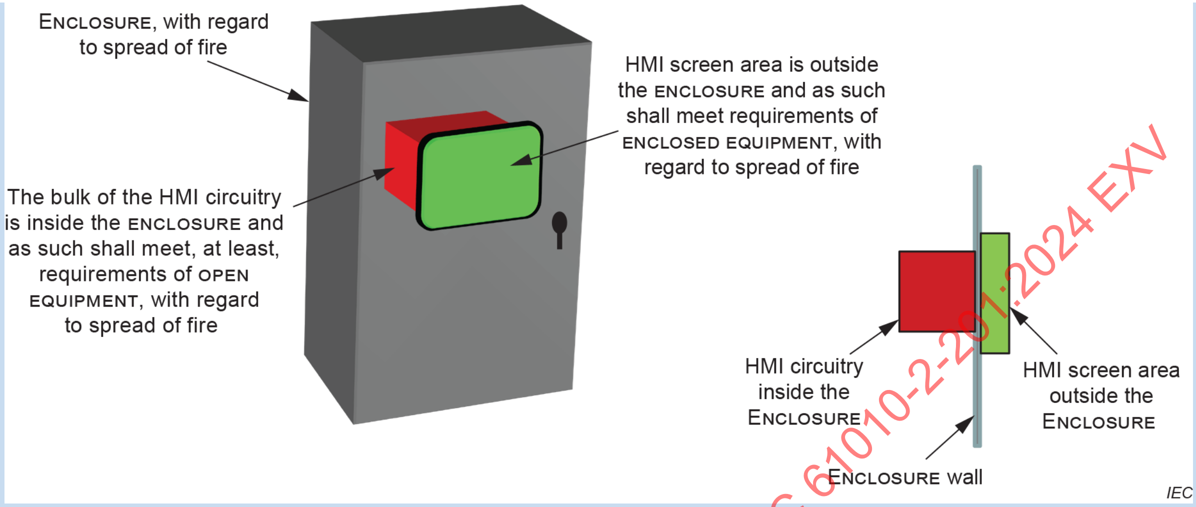


Figure 104 – Spread of fire HAZARDS, with regard to PANEL MOUNTED EQUIPMENT

a) Connectors and insulating material on which components are mounted shall have a flammability classification V-2, or better, of IEC 60695-11-10. See also 14.7 for requirements for printed wiring boards.

SELV/PELV connectors with less than 0,5 A per pin or rated current in normal condition and which contribute negligible fuel to a fire are exempted.

NOTE 3 V-0 is better than V-1, which is better than V-2.

Conformity is checked by inspection of data on materials, and, in case of doubt, by performing the vertical burning test of IEC 60695-11-10 on samples of the material used in the relevant parts.

Or optionally, conformity may be checked by a glow-wire test at 750 °C with a 30 s application and an extinguishing time less than, or equal to, 30 s in accordance with IEC 60695-2-11.

b) Insulated wires and cables shall retard flame propagation.

NOTE 4 A wire with a flammability RATING of UL 2556 VW-1 or equivalent is considered to meet this requirement.

Conformity is checked by inspection of data on materials, and, in case of doubt, by performing whichever of the following tests is applicable:

1) *for wires and cables with an overall cross-sectional area of the conductors exceeding 0,5 mm^2, the test of IEC 60332-1-2;*

2) *for wires and cables with an overall cross-sectional area of the conductors of 0,5 mm^2 or less, the test of IEC 60332-2-2.*

For equipment intended to be placed in a panel or a rack, any wires or cables interconnecting the equipment to other devices, shall also be considered.

SELV/PELV internal wires and cables carrying less than 4 A, in normal condition, and that cannot contribute to the spread of fire are exempted from the flammability requirement.

Conformity is checked by inspection or accompanying documents.

c) The ENCLOSURE shall meet the following requirements:

1) the bottom and sides of the ENCLOSURE within the 5° arc of Figure 13 of circuits that are not limited circuits according to 9.4 shall comply with one of the following requirements:

i) have no openings;

ii) be made of metal with perforations as specified in Table 16;

iii) 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;

iv) have openings with baffles in accordance with Figure 12.

2) the ENCLOSURE and any baffle or flame barrier shall be made of metal or of non-metallic materials having a flammability classification of V-1 or better, of IEC 60695-11-10. If magnesium alloy is used for the ENCLOSURE or a flame barrier, it shall be verified as specified in Annex DD.

3) the ENCLOSURE, and any baffle or flame barrier, shall have adequate rigidity, see Clause 8.

Conformity is checked by inspection. If the ENCLOSURE or flame barrier is made of magnesium alloy, the flammability test of requirement c)2) is checked as specified in Annex DD. In other cases of doubt, the flammability classification of requirement c)2) is checked by performing the vertical burning test of IEC 60695-11-10 on samples of the material used in the relevant parts.

d) For PANEL MOUNTED EQUIPMENT, the portion of the equipment that forms a part of the end use location ENCLOSURE shall be made of a material rated in accordance with, and shall comply with the following:

1) The polymeric part shall close an opening in the ENCLOSURE having an area of not more than 650 mm^2 and shall be:

– Rated V-0, V-1, or V-2; or

– Rated HB and comply with the glow wire test in accordance with IEC 60695-2-11 with a required test temperature of 750°C and with a 30 s application and an extinguishing time less than, or equal to, 30 s.

2) The polymeric part shall close an opening in the ENCLOSURE having an area of more than 650 mm^2 and shall be:

– Rated 5VA or 5VB and subjected to the resistance to mechanical stresses testing in Clause 8; or

– Rated V-0, V-1, V-2 or HB, and shall comply with the 5VA or 5VB flammability test requirement in accordance with IEC 60695-11-20.

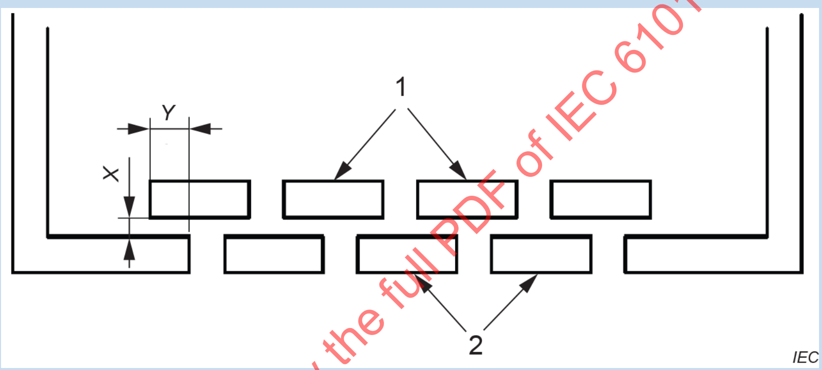
3) If magnesium alloy is used for the portion of the equipment that forms a part of the end use location ENCLOSURE, it shall be verified as specified in Annex DD.

Exception: The polymeric part is not required to be subjected to the flammability test when it encloses only parts that do not pose a risk of fire, as in 9.4 and is protected from exposure to fire by an internal metal barrier, a glass display that complies with 8.2.2.101, or polymeric barrier that complies with the flammability test. A printed wiring board rated V-0 may serve as a polymeric barrier.

Conformity is checked by inspection of the material data sheets and, if necessary, by the appropriate tests.

Table 16 – Acceptable perforation of the bottom of an ENCLOSURE

Minimum thickness mm	Maximum diameter of holes mm	Minimum spacing of holes centre to centre mm
0,66	1,14	1,70 (233 holes / 645 mm^2)
0,66	1,19	2,36
0,76	1,15	1,70
0,76	1,9	2,36
0,81	1,91	3,18 (72 holes / 645 mm^2)
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



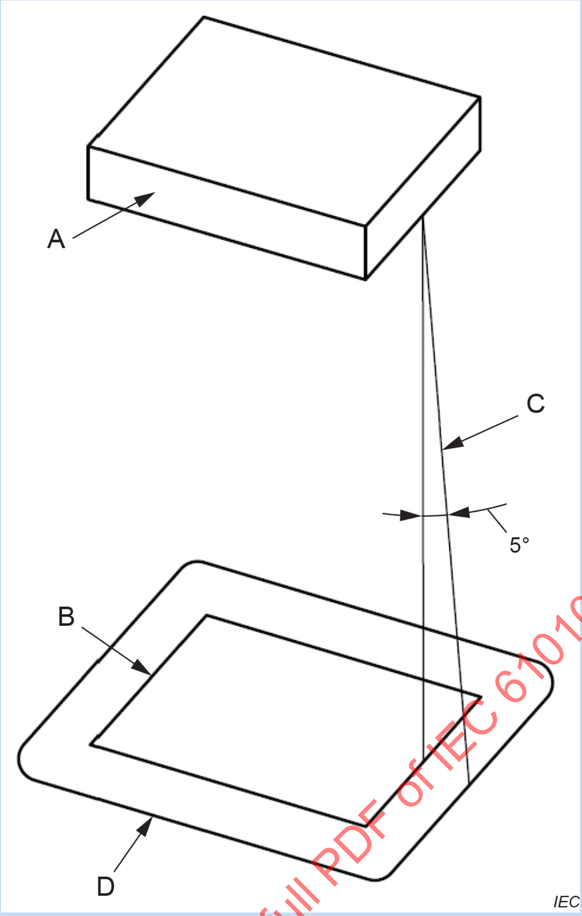
$Y \geq X$ but never less than 25 mm

Key

1 Baffle plates (may be below the bottom of the ENCLOSURE)

2 Bottom of the ENCLOSURE

Figure 12 – 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 9.3.2 c) 1) and 9.3.2 c) 2). 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 9.3.2 c) 1).

Figure 13 – Area of the bottom of an ENCLOSURE to be constructed as specified in 9.3.2 c) 1)

9.4 Limited-energy circuit

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

a) The voltage appearing in the circuit is not more than 30 V r.m.s., 42,4 V peak, or 60 V d.c.

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 applicable value of Table 17;

  2) current is limited by an overcurrent protection device so that it cannot exceed the applicable values of Table 18;

  3) a regulating network limits the maximum available current so that it cannot exceed the relevant value of Table 17 in NORMAL CONDITION or as a result of a fault in the regulating network.

c) It is separated by at least BASIC INSULATION from other circuits having energy values exceeding criteria a) or b) above.

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

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

i) the potentials appearing in the circuit are measured in the load condition that maximizes the voltage;

ii) output current is measured after 60 s of operation, with the resistive load (including short circuit) which produces the highest value of current.

Table 17 – Limits of maximum available current

Open-circuit output voltage (*U or Û*) V			**Maximum available current** A
a.c. r.m.s.	**d.c.**	**Peak**[a]	**a.c. r.m.s. or d.c.**
$U \le 2$	$U \le 2$	$\hat{U} \le 2,8$	50
$2 < U \le 12,5$	$2 < U \le 12,5$	$2,8 < \hat{U} \le 17,6$	$100 / U$
$12,5 < U \le 18,7$	$12,5 < U \le 18,7$	$17,6 < \hat{U} \le 26,4$	8
$18,7 < U \le 30$	$18,7 < U \le 60$	$26,4 < \hat{U} \le 42,4$	$150 / U$

[a] The peak value ($\hat{U}$) applies to non-sinusoidal a.c. and to d.c. with ripple exceeding 10 %, and is provided for convenience. The r.m.s. value of the maximum available current shall be determined as that value is related to heating.

Table 18 – Values for overcurrent protection devices

Potential appearing in the circuit (*U or Û*) V			Current that the device breaks after not more than 120 s[b c] A
a.c. r.m.s.	**d.c.**	**Peak [a]**	**a.c. r.m.s. or d.c.**
$U \leq 2$	$U \leq 2$	$\hat{U} \leq 2{,}8$	62,5
$2 < U \leq 12{,}5$	$2 < U \leq 12{,}5$	$2{,}8 < \hat{U} \leq 17{,}6$	125 / U
$12{,}5 < U \leq 18{,}7$	$12{,}5 < U \leq 18{,}7$	$17{,}6 < \hat{U} \leq 26{,}4$	10
$18{,}7 < U \leq 30$	$18{,}7 < U \leq 60$	$26{,}4 < \hat{U} \leq 42{,}4$	200 / U

[a] The peak value ($\hat{U}$) applies to non-sinusoidal a.c. and to d.c. with ripple exceeding 10 %, and is provided for convenience. The r.m.s. value of the maximum available current shall be determined as that value is related to heating.

[b] The evaluation is based on the specified time-current breaking characteristic of the device, which is different from the RATED breaking current. (For example, an ANSI/UL 248-14 5 A fuse is specified to break 10 A at 120 s or less and an IEC 60127 T-type 4 A fuse is specified to break at 8,4 A at 120 s or less.)

[c] The breaking current of fuses is dependent on temperature, and this has to be taken into account if the temperature immediately around the fuse is significantly higher than the room temperature.

9.5 Requirements for equipment containing or using flammable liquids

Flammable liquids contained in, or specified for use with, the equipment shall not cause the spread of fire in NORMAL CONDITION or in SINGLE FAULT CONDITION.

The HAZARDS arising from flammable liquids are considered to be reduced to a tolerable level if one of the following requirements is met.

a) The temperature of the surface of the liquid and parts in contact with the surface, in NORMAL CONDITION and SINGLE FAULT CONDITION, is limited to a temperature not exceeding t – 25 °C, where t is the fire point of the liquid (see 10.3 b)).

NOTE 1 Fire point is the temperature to which a liquid must be heated (under specified conditions) so that the vapour/air mixture at the surface will support a flame for at least 5 s when an external flame is applied and withdrawn.

b) The quantity of liquid is limited to an amount that could not cause the spread of fire.

c) If the liquid can be ignited, the flames are contained to prevent the spread of fire outside the equipment. Detailed instructions for use shall be provided to establish adequate RISK reduction procedures.

Conformity with a) and b) is checked by inspection and by temperature measurement as specified in 10.4.

Conformity with c) is checked as specified in 4.4.4.3.

NOTE 2 For liquids with toxic combustion by-products, it may be convenient to use a different liquid with similar burn characteristics for testing purposes.

9.6 Overcurrent protection

9.6.1 General

Equipment intended to be energized from a MAINS supply shall be protected by fuses, circuit-breakers, thermal cut-outs, impedance limiting circuits or similar means, to provide protection against excessive current being drawn from the MAINS in case of a fault in the equipment.

NOTE 1 Overcurrent protection devices supplied with the equipment are intended to provide protection against faults which result in increased current flow, and therefore, increased heating and the probability of the start and spread of fire. These devices are not intended to provide protection against short-circuits between MAINS conductors and protective earth conductors. The building installation contains overcurrent protection devices in each unearthed MAINS conductor which are intended to protect against short-circuits between the MAINS conductor and protective earth. The breaking capacity of the overcurrent protection device should be compatible with the current RATING of the installation.

A minimum of BASIC INSULATION is required between MAINS-connected parts of opposite polarity on the supply side of the overcurrent protection device.

Overcurrent protection devices shall not be fitted in the protective conductor. Fuses or single pole circuit-breakers shall not be fitted in the neutral conductor of multi-phase equipment.

NOTE 2 Overcurrent protection devices (for example, fuses) should preferably be fitted in all supply conductors. If fuses are used as overcurrent protection devices, the fuse holders should be mounted adjacent to each other. The fuses should be of the same RATING and characteristic. Overcurrent protection devices should preferably be located on the supply side of the MAINS CIRCUITS in the equipment, including any MAINS switch. It is recognized that, in equipment generating high frequencies, it is essential for the interference suppression components to be located between the MAINS supply and the overcurrent protection devices.

Conformity is checked by inspection and by measurement, and for solid insulation by the a.c. voltage test of 6.8.3.1 or the d.c. voltage test of 6.8.3.2 (without humidity preconditioning) using the test voltage from Table 5 for BASIC INSULATION for the appropriate line-to-neutral voltage for 1 min. EMC capacitors meeting the requirements of Clause 14 may be disconnected during the voltage test.

9.6.2 PERMANENTLY CONNECTED EQUIPMENT

Overcurrent protection devices are optional in PERMANENTLY CONNECTED EQUIPMENT. If none are fitted, the installation instructions shall specify the characteristics of the overcurrent protection devices required in the building installation.

Conformity is checked by inspection.

9.6.3 Other equipment

If an overcurrent protection device is provided, it shall be within the equipment.

Conformity is checked by inspection.

10 Equipment temperature limits and resistance to heat

10.1 Surface temperature limits for protection against burns

The temperature of easily touched surfaces shall not exceed the values of Table 19 in NORMAL CONDITION, and 105 °C in SINGLE FAULT CONDITION, at an ambient temperature of 40 °C.

Easily touched surfaces of equipment RATED for a maximum ambient temperature above 40 °C are permitted to exceed the values of Table 19 in NORMAL CONDITION, and to exceed 105 °C in SINGLE FAULT CONDITION, by not more than the amount by which the maximum RATED temperature exceeds 40 °C.

If easily touched heated surfaces are necessary for the processing or heating of materials, or where otherwise not avoidable, they are permitted to exceed the values of Table 19 in NORMAL CONDITION and to exceed 105 °C in SINGLE FAULT CONDITION, provided that they are recognizable as such by appearance or function or are marked with symbol 13 of Table 1. Equipment heated by its environment to temperature values exceeding the values in Table 19 in NORMAL CONDITION and 105 °C in SINGLE FAULT CONDITION need not to be marked with symbol 13.

Surfaces protected by barriers that prevent them from being touched accidentally are not considered to be easily touched surfaces, provided that the barriers cannot be removed without the use of a TOOL.

Table 19 – Surface temperature limits, under NORMAL CONDITION

Part		ENCLOSED EQUIPMENT °C	OPEN EQUIPMENT °C
1	Outer surface of ENCLOSURE or barrier (unintentional contact)		
	a) metal uncoated or anodized	65	70
	b) metal coated (paint, non-metallic)	80	85
	c) plastics	85	85
	d) glass and ceramics	80	85
	e) small areas (< 2 cm^2) that are not likely to be touched in NORMAL USE	100	100
2	Knobs and handles (NORMAL USE contact)		
	a) metal	55	55
	b) plastics	70	70
	c) glass and ceramics	65	70
	d) non-metallic parts that in NORMAL USE are held only for short periods (1 s to 4 s)	70	85

NOTE 1 NORMAL USE contact could be surfaces touched by an OPERATOR in NORMAL USE or by SERVICE PERSONNEL.

NOTE 2 This table is based on IEC Guide 117.

For equipment with a RATED AMBIENT TEMPERATURE above 40 °C, higher temperatures are possible. See IEC 61010-1:2010, 10.1 and IEC 61010-1:2010/AMD1:2016, 10.1. See 5.4.4 item j) of this document.

Conformity is checked by measurement as specified in 10.4, and by inspection of barriers to check that they protect against accidentally touching surfaces that are at temperatures above the values of Table 19, and that they cannot be removed without a TOOL.

10.2 Temperatures of windings

If a HAZARD could be caused by excessive temperature, the temperature of the insulating material of windings shall not exceed the values of Table 20 in NORMAL CONDITION and SINGLE FAULT CONDITION.

Conformity is checked by measurement as specified in 10.4, in NORMAL CONDITION and in the applicable SINGLE FAULT CONDITIONS of 4.4.2.5, 4.4.2.10 and 4.4.2.11, and also in any other SINGLE FAULT CONDITIONS that could cause a HAZARD as a result of excessive temperature.

Table 20 – Maximum temperatures for insulation material of windings

Class of insulation (see IEC 60085)	NORMAL CONDITION °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

10.3 Other temperature measurements

The following other measurements are made, if applicable, for the purposes of other sub-clauses. Tests are made in NORMAL CONDITION unless stated.

a) The temperature of a field-wiring TERMINAL box or compartment is measured if there is a possibility that it could exceed 60 °C at an ambient temperature of 40 °C, or the maximum RATED ambient temperature if higher (in connection with the marking requirement of 5.1.8). This does not apply to control equipment FIELD WIRING, e.g. I/Os or to TERMINAL boxes for control equipment FIELD WIRING which do not contain power consuming parts.

b) The temperature of the surface of flammable liquids, and parts in contact with the surface, is measured in the SINGLE FAULT CONDITIONS of 4.4.2.10 and 4.4.2.11 (in connection with 9.5 a)).

c) The temperature of non-metallic ENCLOSURES is measured during the test of 10.5.1 (to establish a base temperature for the test of 10.5.2).

d) The temperature of parts made of insulating material which are used to support parts connected to the MAINS supply (to establish a temperature for test 1) of 10.5.3).

e) The temperature of TERMINALS carrying a current exceeding 0,5 A if substantial heat could be dissipated in case of poor contact (to establish a temperature for test 1) of 10.5.3).

aa) FIELD WIRING TERMINALS' temperature shall be monitored during the temperature test. This data shall be used in conjunction with the device's RATED AMBIENT TEMPERATURE to determine the FIELD WIRING insulation temperature requirements.

10.4 Conduct of temperature tests

10.4.1 General

10.4.1.101 General method

Equipment under test (EUT) shall be tested under reference test conditions. The reference test AMBIENT TEMPERATURE shall be the same as the maximum RATED AMBIENT TEMPERATURE, as defined in IEC 61010-1:2010, 1.4.1 c) or 1.4.2 c).

NOTE 1 RATED AMBIENT TEMPERATURE can be referenced in other terminology, e.g. RATED operating temperature, or designation, such as Ta.

The installation instructions concerning ventilation, cooling liquid, limits for intermittent use, etc. are followed, unless a particular SINGLE FAULT CONDITION specifies otherwise. Any cooling liquid shall be at the highest RATED temperature.

The EUT shall be mounted in its least favourable position or orientation.

The EUT shall be generating its least favourable heat dissipation. This dissipation may be caused by some combination of load current, input voltage, input frequency, I/O duty cycle, etc.

A digital or switching output rated with a contact code designation for pilot duty shall be tested with the thermal current (I_{the}) correlating with the designation in IEC 60947-5-1:2016, Table A.1, IEC 61810-1:2015, Table B.4 or the rated load current, whichever is higher.

The EUT FIELD WIRING *shall be the smallest size suitable for the maximum current rating of the EUT in accordance with installation instructions.*

The environment surrounding the EUT during the test (volume is not a criteria) shall not be subjected to air movement caused by sources not part of the EUT, i.e. it shall be a natural convection environment. See Figure 105.

To reduce and block forced air movement in a test room or in a climatic chamber around the EUT, the EUT may be placed in a partially or completely closed test box allowing air movement or natural convection only caused by the EUT. Or barriers made of any suitable material may be used around the EUT, to block air movement.

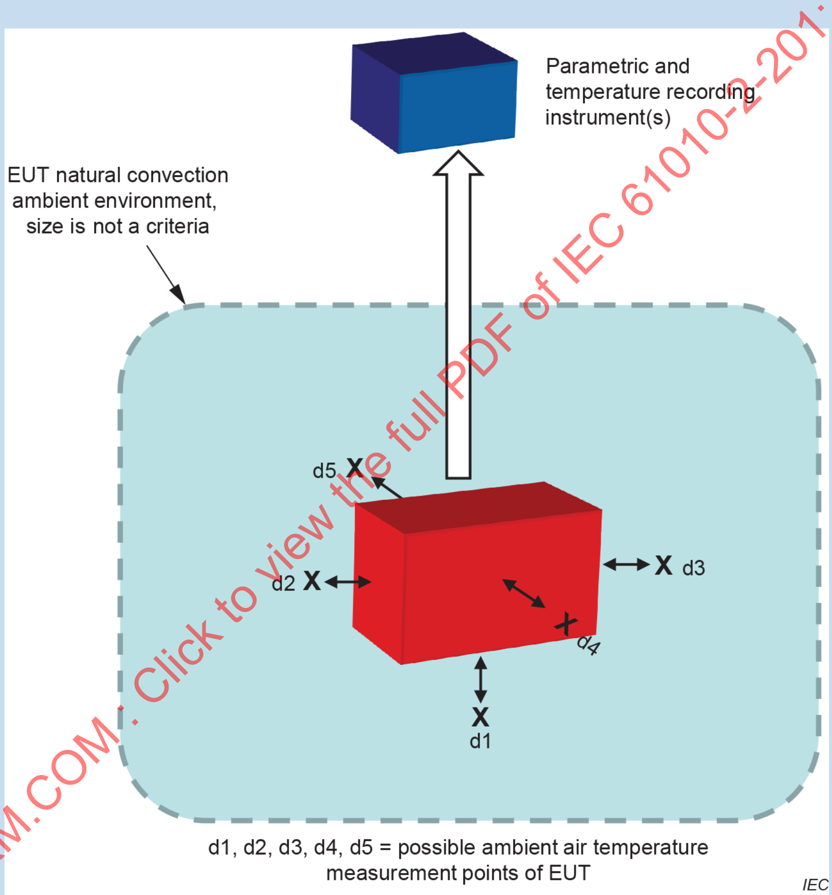


Figure 105 – General temperature test environment

Temperatures are measured when steady state has been reached. Steady state is defined as temperature rise of less than 2 K within 1 h.

If the EUT is meant to function as a stand-alone unit it shall be tested stand-alone, for example a stand-alone HMI or communication router.

If the EUT is not meant to function as a stand-alone unit, for example I/O module of a modular equipment system, then a representative system shall be utilized for testing. This system shall represent a practical least favourable combination of conditions for the EUT.

NOTE 2 A practical least favourable combination of conditions means a realistic situation the EUT can be utilized for in a real world application, not a theoretical combination which would be improbable.

This practical least favourable combination shall be, at a minimum, the items necessary for the EUT to function, for example power supply, communication module (TMs in Figure 106) and EUT. The EUT shall be surrounded, as permitted by installation documentation, on both sides with real modules or "simulation modules" (thermally representative modules, TMs in Figure 106) representing the worst case thermal environment for the EUT, i.e. adding more modules around the EUT does not cause further temperature increase of the EUT. A justification of the configuration for the test shall be provided in the test report.

An example configuration for testing an I/O module EUT, of a modular system, can be:

- *the EUT (I/O module),*
- *a power supply,*
- *communication module,*
- *three of the same type I/O module operating at full load to the left of the EUT,*
- *three of the same type I/O module operating at full load to the right of the EUT, and*
- *adding more I/O modules left or right does not cause the EUT's temperature to change.*

For vented equipment, cooled by natural air convection, the AMBIENT TEMPERATURE is the incoming air temperature at a point not more than 50 mm and not less than 25 mm away from the plane of the equipment's air flow entry point. See Figure 106. The points d1, d2 and d3, in Figure 106, are the possible measurement points. The point with the lowest temperature should be utilized as the AMBIENT TEMPERATURE.

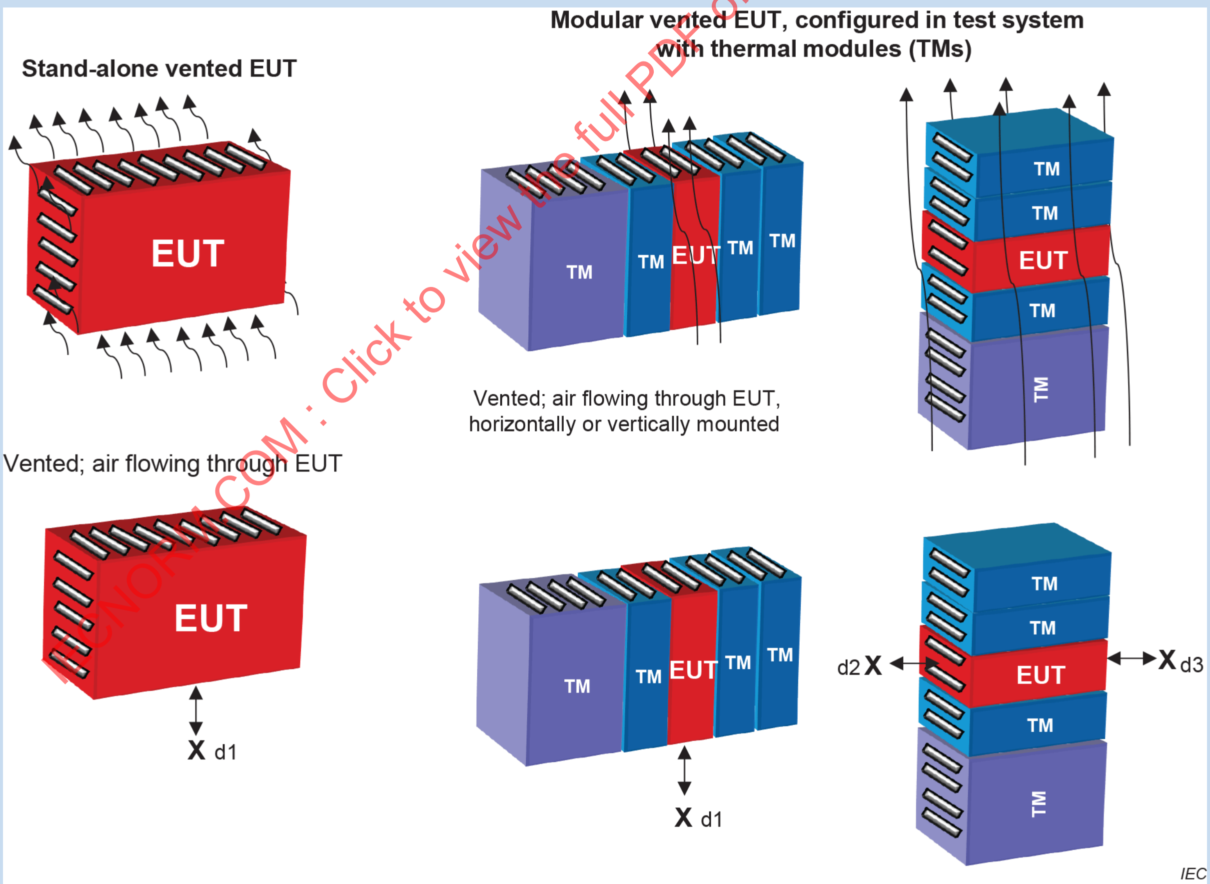


Figure 106 – Vented equipment

NOTE 3 Vents are purposeful air openings intended to enable air to pass through the equipment for the purpose of cooling, not incidental vents, e.g. switch shaft or communication jack openings.

For non-vented equipment, cooled by natural air convection, the AMBIENT TEMPERATURE *is the air temperature at a point not more than 50 mm and not less than 25 mm away from the equipment, on a horizontal plane located at the vertical mid-point of the equipment. See Figure 107. The points d2 to d5 in Figure 107 are the possible measurement points. The point with the lowest temperature should be utilized as the* AMBIENT TEMPERATURE*.*

Because of mounting requirements, some of the measurement points will possibly not be practical to utilize.

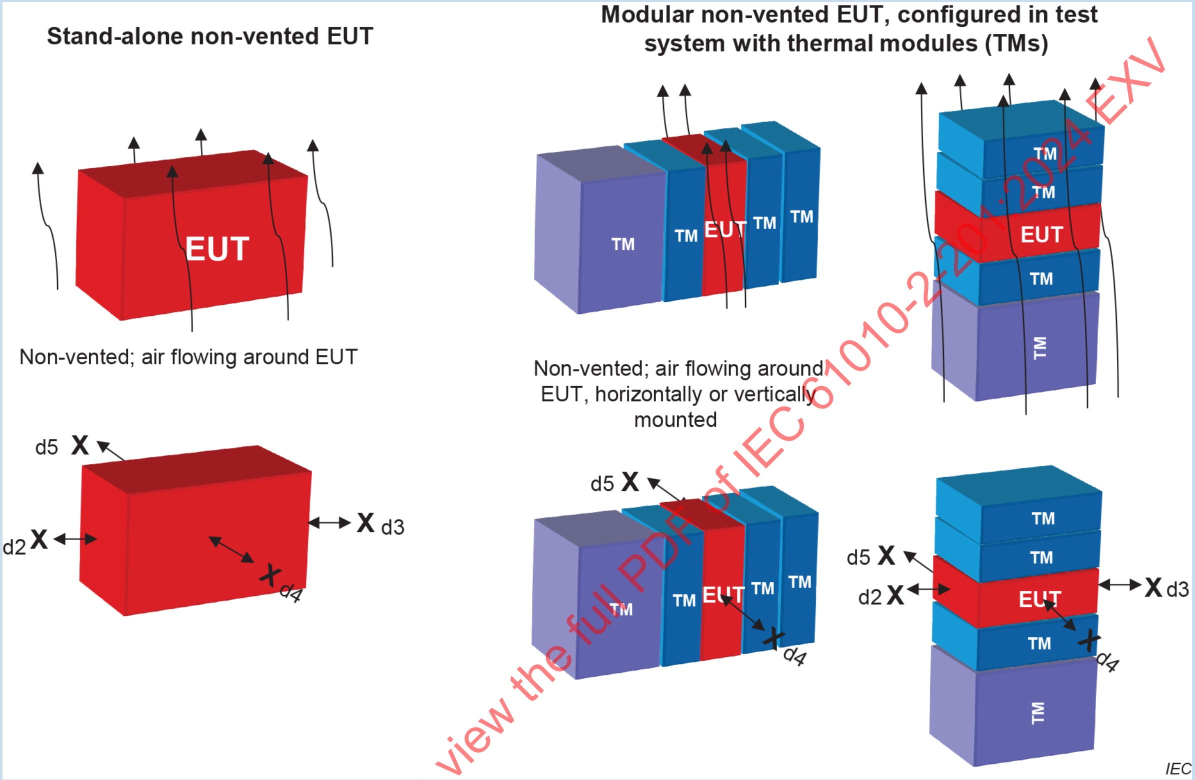


Figure 107 – Non-vented equipment

10.4.1.102 Special method, PANEL MOUNTED EQUIPMENT

PANEL MOUNTED EQUIPMENT *presents some special considerations, see Figure 108.*

In this case, part of the equipment (EUT$_a$) can be in one ambient environment, for example ambient environment #1 and the rest of the equipment (EUT$_b$) can be in another ambient environment, for example ambient environment #2. The equipment construction techniques can be quite different, for example (referring to Figure 108) open/vented in ambient environment #1 and enclosed/non-vented in ambient environment #2.

It should be kept in mind, it can be necessary that these two different environments be applied simultaneously, to ensure least favourable conditions.

Each part of the equipment (EUT$_a$ and EUT$_b$) shall be evaluated separately according to its own environment.

The general method described in 10.4.1.101 with regard to test conditions and least favourable EUT configuration, orientation, etc. shall be followed.

Three special methods for testing PANEL MOUNTED EQUIPMENT *are provided:*

a) *The equipment shall be mounted such that the two portions (EUT_a and EUT_b) of the EUT are subjected to their specific environments.*

NOTE 1 This provides the most accurate results, but is the most difficult to create for a test.

b) *The total EUT (EUT_a + EUT_b) shall be mounted in a single environment, which shall be the higher* RATED *temperature of the two, and the recorded temperatures of the lower* RATED *temperature EUT portion are corrected by the difference between the EUT's maximum* RATED AMBIENT TEMPERATURE *and the actual test* AMBIENT TEMPERATURE.

EXAMPLE 1 If EUT_a's maximum RATED AMBIENT TEMPERATURE = 60 °C and EUT_b's maximum RATED AMBIENT TEMPERATURE = 50 °C, the test shall be run with a test AMBIENT TEMPERATURE = 60 °C. Temperatures taken for EUT_b would be corrected by –10 °C (50 °C – 60 °C).

NOTE 2 This method is not as accurate as a) but will yield conservative results compared to c).

c) *The total EUT (EUT_a + EUT_b) shall be mounted in a single environment, which shall be the lower* RATED *temperature of the two, and the recorded temperatures of the higher* RATED *temperature EUT portion are corrected by the difference between the EUT's maximum* RATED AMBIENT TEMPERATURE *and the actual test* AMBIENT TEMPERATURE.

EXAMPLE 2 If EUT_a's maximum RATED AMBIENT TEMPERATURE = 60 °C and EUT_b's maximum RATED AMBIENT TEMPERATURE = 50 °C, the test shall be run with a test AMBIENT TEMPERATURE = 50 °C. Temperatures taken for EUT_a would be corrected by +10 °C (60 °C – 50 °C).

NOTE 3 This method is not as accurate as a) and will not yield conservative results compared to b).

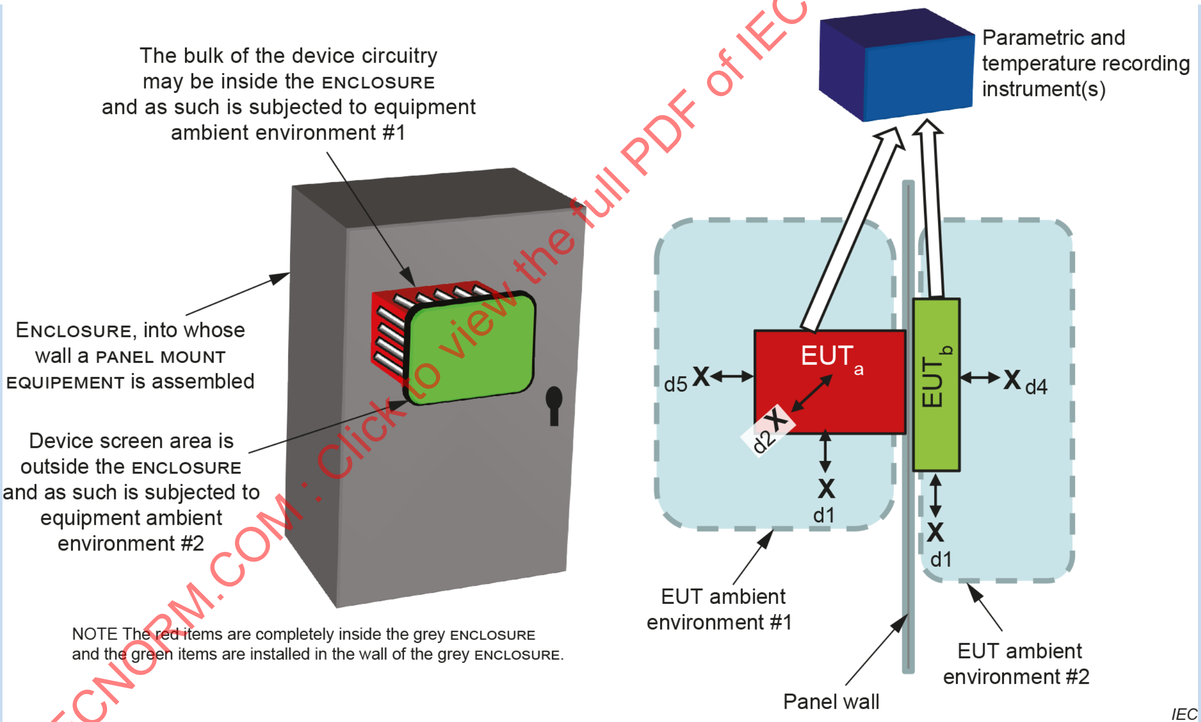


Figure 108 – PANEL MOUNTED EQUIPMENT extending through the wall of the end location ENCLOSURE

10.4.1.103 Special method, large or heavy equipment

Equipment too large or too heavy may be tested at room AMBIENT TEMPERATURE, if the recorded temperatures are corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test room AMBIENT TEMPERATURE.

Where this method is applied, a rationale shall be provided in the test report.

10.4.1.104 Other considerations, applying to all cases

Other considerations for temperature testing:

a) The temperature of insulating material of windings is measured as the temperature of winding wire and of core lamination in contact with the insulating material. It can be determined by the resistance method or by using temperature sensors selected and positioned so that they have a negligible effect on the temperature of the winding. The latter method may be used if the windings are non-uniform or if it is difficult to measure resistance.
b) Because of the difficulty of setup and repeat for single fault tests, these tests may be done at room AMBIENT TEMPERATURE. The recorded temperatures shall be corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test room AMBIENT TEMPERATURE.

10.4.2 Temperature measurement of heating equipment

IEC 61010-1:2010, Subclause 10.4.2 is not applicable.

10.4.3 Equipment intended for installation in a cabinet or a wall

Such equipment is built in as specified in the installation instructions, using walls of plywood painted matt black, approximately 10 mm thick when representing the walls of a cabinet, approximately 20 mm thick when representing the walls of a building.

10.5 Resistance to heat

10.5.1 Integrity of CLEARANCES and CREEPAGE DISTANCES

CLEARANCES and CREEPAGE DISTANCES shall meet the requirements of 6.7 when the equipment is operated at an ambient temperature of 40 °C, or the maximum RATED ambient temperature if higher.

Conformity, in cases of doubt if the equipment produces an appreciable amount of heat, is checked by operating the equipment under the reference test conditions of 4.3, except that the ambient temperature is 40 °C, or the maximum RATED ambient temperature if higher. After this test, CLEARANCES and CREEPAGE DISTANCES shall not have been reduced below the requirements of 6.7.

If the ENCLOSURE is non-metallic, the temperature of parts of the ENCLOSURE is measured during the above test for the purposes of 10.5.2.

10.5.2 Non-metallic ENCLOSURES

This subclause is applicable for ENCLOSED EQUIPMENT.

ENCLOSURES of non-metallic material shall be resistant to elevated temperatures.

Conformity is checked by test, after one of the following treatments.

a) *A non-operative treatment, in which the equipment, not energized, is stored for 7 h at 70 °C ± 2 °C, or at 10 °C ± 2 °C above the temperature measured during the test of 10.5.1, whichever is higher. If the equipment contains components that might be damaged by this treatment, an empty ENCLOSURE may be treated, followed by assembly of the equipment at the end of the treatment.*
b) *An operative treatment, in which the equipment is operated under the reference test conditions of 4.3, except that the ambient temperature is 20 °C ± 2 °C above 40 °C, or above the maximum RATED ambient temperature if higher than 40 °C.*

Within 10 minutes of the end of treatment the equipment shall be subjected to the suitable stresses of 8.2 and 8.3, and meet the pass criteria of 8.1.

10.5.3 Insulating material

Insulating material shall have adequate resistance to heat.

a) Parts that are made of insulating material, and which are used to support other parts that are connected to the MAINS supply, shall be made of insulating materials that will not cause a HAZARD if short circuits occur inside the equipment.

b) If in NORMAL USE, TERMINALS carry a current exceeding 0,5 A and if substantial heat could be dissipated in case of poor contact, the insulation which supports the TERMINALS shall be made of material that will not soften to an extent that could cause a HAZARD or further short circuits.

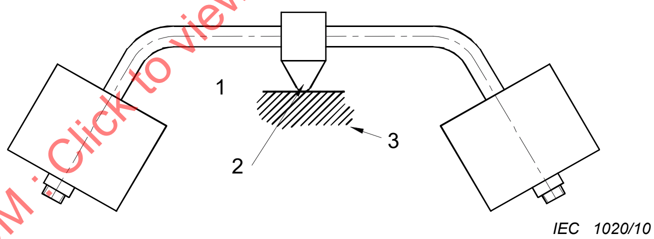
In case of doubt, conformity is checked by examination of material data. If the material data is not conclusive, one of the following tests is performed.

1) *A sample of the insulating material, at least 2,5 mm thick, is subjected to a ball-pressure test using the test apparatus Figure 14. The test is made in a heating cabinet at the temperature measured as specified in 10.3 d) or 10.3 e) ± 2 °C, or at 125 °C ± 2 °C, whichever is higher. The part to be tested is supported so that its upper surface is horizontal, and the spherical part of the apparatus is pressed against this surface with a force of 20 N. After 1 h the apparatus is removed and the sample is cooled within 10 s to approximately room temperature by immersion in cold water. The diameter of the impression caused by the ball shall not exceed 2 mm.*

   NOTE 1 If necessary, the required thickness may be obtained by using two or more sections of the part.

   NOTE 2 For bobbins, only those parts that support or retain TERMINALS in position are subjected to the test.

   NOTE 3 See IEC 60695-10-2 for more information about this test.



Key

1 Part to be tested

2 Spherical part of the apparatus (diameter 5 mm)

3 Support

Figure 14 – Ball-pressure test apparatus

2) *The Vicat softening test of ISO 306, method A120. The Vicat softening temperature shall be at least 130 °C.*

11 Protection against HAZARDS from fluids and solid foreign objects

11.1 General

Equipment shall be designed to give protection to OPERATORS and the surrounding area against HAZARDS from fluids and solid foreign objects encountered in NORMAL USE.

NOTE 1 Fluids likely to be encountered fall into three categories:

a) those having continuous contact, for example, in vessels intended to contain them;

b) those having occasional contact, for example, cleaning fluids;

c) those having accidental (unexpected) contact. The manufacturer cannot safeguard against such cases.

Fluids specified by the manufacturer, including cleaning and decontaminating fluids, are considered. Other fluids are not considered.

NOTE 2 The term “fluids” includes both liquids and gases.

NOTE 3 All pressures in Clause 11 are gauge pressures.

Conformity is checked by the treatment and tests of 11.2 to 11.7 as applicable.

11.2 Cleaning

If a cleaning or decontamination process is specified by the manufacturer, this shall not cause a direct HAZARD, nor an electrical HAZARD, nor a HAZARD resulting from corrosion or other weakening of structural parts relied upon for safety.

Conformity is checked by cleaning the equipment three times if a cleaning process is specified and decontaminating the equipment once if a decontamination process is specified, in accordance with the manufacturer's instructions. If, immediately after this treatment, there are any signs of wetting of parts likely to cause a HAZARD, the equipment shall pass the voltage tests of 6.8 (without humidity preconditioning) applicable to the type of insulation (see 6.7) and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

11.3 Spillage

If, in NORMAL USE, liquid is likely to be spilt into the equipment, the equipment shall be designed so that no HAZARD will occur, for example as a result of the wetting of insulation or of internal uninsulated parts, or as a result of the contact of potentially aggressive substances (such as corrosive, toxic or flammable liquids) with parts of the equipment.

If in NORMAL USE potentially aggressive substances (such as corrosive, toxic or flammable liquids) are likely to be spilt on parts of the equipment, the wetted material should be analyzed to determine compatibility with the aggressive substance.

Conformity is checked by inspection. In case of doubt, 0,2 l of water is poured steadily from a height of 0,1 m over a period of 15 s onto each point in turn where liquid might gain access to electrical parts. Immediately after this treatment, the CLEARANCES and solid insulation shall pass the voltage tests of 6.8 (without humidity preconditioning) applicable to the type of insulation (see 6.7) and ACCESSIBLE parts shall not exceed the limits of 6.3.1.

11.4 Overflow

Liquid overflowing from any container in the equipment which can be overfilled shall not cause a HAZARD during NORMAL USE, for example as a result of the wetting of insulation or of internal uninsulated parts that are HAZARDOUS LIVE.

Equipment likely to be moved while a container is full of liquid shall be protected against liquid surging out of the container.

Conformity is checked by the following treatment and tests. The liquid container is completely filled. A further quantity of liquid equal to 15 % of the capacity of the container or 0,25 l, whichever is the greater, is then poured in steadily over a period of 60 s. If equipment is likely to be moved while a container is full of liquid, it is then tilted 15° in the least favourable direction from the position of NORMAL USE. Immediately after this treatment, the CLEARANCES and solid insulation shall pass the voltage tests of 6.8 (without humidity preconditioning) *applicable to the type of insulation (see 6.7) and ACCESSIBLE parts shall not exceed the limits 6.3.1.*

11.5 Battery electrolyte

Batteries shall be so mounted that safety cannot be impaired by leakage of their electrolyte.

NOTE Also see 13.2.2.

Conformity is checked by inspection.

11.6 Equipment RATED with a degree of ingress protection (IP code)

11.6.1 General

Equipment RATED by the manufacturer as conforming to one of the degrees of protection as defined in IEC 60529 shall adequately resist the ingress of solid foreign objects and water which could lead to a HAZARD.

Equipment may have different degrees of protection depending on the mounting arrangements, or the assembly or operating conditions. The degrees of protection shall be specified in the documentation for each mounting arrangement. If the degree of protection depends on particular positions, covers, seals, or operating conditions, these conditions shall be specified in the documentation.

If the RATING is marked on the equipment, it shall be marked on the equipment in a manner to avoid misunderstanding and misuse. The designations of IEC 60529 shall be used (IP code). The IP code and related operating or non-operating conditions shall be explained in the documentation together with other warnings.

For IPx8 testing, the water level above the equipment and the test duration shall be applied as specified in the documentation. The aforementioned conditions shall be more severe than those for IPx7 according to IEC 60529.

Conformity is checked by inspection and as specified in 11.6.2 to 11.6.4 as applicable.

11.6.2 Conditions for testing

The equipment shall be in a clean and new condition with all parts in place and mounted in the manner defined by the manufacturer. If it is impracticable to test the complete equipment, representative parts or smaller equipment having the same full-scale design details shall be tested.

HAND-HELD EQUIPMENT is placed in the least favourable position. Portable equipment is placed in the least favourable position of normal use. Other equipment is positioned or installed as specified in the installation instructions.

TERMINALS are considered to be part of the equipment. However, TERMINALS provided with a protective cap or cover necessary to maintain the rated degree of protection are installed as specified by the manufacturer.

The equipment is operating (energized) during the treatment except

a) if the manufacturer specifies degrees of protection for non-operating (de-energized) equipment, or
b) if, whether the equipment is operating or not operating during the treatment does not affect the test results.

EXAMPLE 1 A field housing contains electronics. Generally in this case it has no influence on the test results whether the electronics inside is operated or not. So the testing of the equipment can also be conducted without the electronics built in.

EXAMPLE 2 An equipment enclosure has a rotating shaft protruding from it using an appropriate seal for the relevant ingress protection rating. In this case the rotation of the shaft is considered as affecting the test results.

11.6.3 Protection against solid foreign objects (including dust)

The applicable test of IEC 60529 for protection against solid foreign objects is performed.

After the test, conformity is checked by inspection of the sample according to the acceptance criteria of IEC 60529.

Additionally, the equipment is inspected for ingress of foreign objects. In particular, they shall not:

a) *deposit on insulation parts where it could lead to a* HAZARD*;*
b) *create accumulations that have the potential to cause the spread of fire.*

NOTE A HAZARD could be caused by the bridging of conductive parts by conductive dust, or by non-conductive dust made wet by humidity.

11.6.4 Protection against water

The applicable test of IEC 60529 for protection against water is performed.

The equipment is inspected for ingress of water. If any water has entered, it shall not impair safety. In particular, it shall not:

a) *deposit on insulation parts where it could lead to a hazard;*
b) *reach hazardous live parts or windings not designed to operate when wet;*
c) *accumulate near the end of a cable or enter the cable where it could cause a hazard;*
d) *accumulate where it could lead to a* HAZARD *taking in consideration movement of the equipment.*

11.7 Fluid pressure and leakage

11.7.1 Maximum pressure

The maximum pressure to which a part of the equipment can be subjected in NORMAL USE or SINGLE FAULT CONDITION shall not exceed the RATED maximum working pressure for the part.

The maximum pressure shall be considered to be the highest of the following:

a) the RATED maximum supply pressure specified for an external source;
b) the pressure setting of an overpressure safety device provided as part of the assembly;
c) the maximum pressure that can be developed by a pressure generating device that is part of the assembly, unless the pressure is limited by an overpressure safety device.

Conformity is checked by inspection of the RATINGS *of the parts and, if necessary, by measuring pressures.*

NOTE Equipment meeting the requirements of 11.7 may not be accepted as conforming to national requirements relating to high pressures. Annex G describes requirements and tests which are accepted as evidence of conformity with national regulations in the USA, in Canada, and in some other countries.

11.7.2 Leakage and rupture at high pressure

Fluid-containing parts which in NORMAL USE have both of the following characteristics shall not cause a HAZARD through rupture or leakage:

a) a product of pressure and volume greater than 200 kPa·l;

b) a pressure greater than 50 kPa.

National authorities may allow safety to be established by calculation, for example according to the Pressure Equipment Directive (2014/68/EU).

Conformity is checked by inspection and, if a HAZARD could arise, by the following hydraulic test.

The test pressure (P_{test}) is the maximum pressure (P_{max}) multiplied by the applicable factor of Figure 16. Any overpressure safety device which could limit the test pressure is deactivated during the test.

The test pressure is raised gradually to P_{test} and is held at that value for 1 min. The sample shall not burst, suffer from permanent (plastic) deformation, or leak. Provided that the test pressure is maintained, leakage at a gasket during these tests is not considered a failure unless it occurs at a pressure of below 75 % of P_{test}, or below P_{max}, whichever is greater.

No leakage is allowed from fluid-containing parts intended for toxic, flammable, or otherwise hazardous substances if it could be a HAZARD.

If fluid-containing parts cannot be hydraulically tested, integrity may be verified by other suitable tests, for example, pneumatic tests using suitable media, at the same test pressure as for the hydraulic test.

As an exception to the above requirements, fluid-containing parts of refrigeration systems shall meet the relevant pressure-related requirements of EN 378-2 or IEC 60335-2-89 as applicable.

Conformity is checked as specified in EN 378-2 or IEC 60335-2-89 as applicable.

Pneumatic overpressure tests should only be conducted if no other option is available. This test can be extremely hazardous. The sudden release of stored energy due to a rupture of the test specimen can lead to severe injury or death. The stored energy in the pressurized system should be understood and appropriate safeguards put in place. These tests should only be conducted behind an explosion shield or within a suitable enclosure to protect laboratory personnel from flying debris, audible hazards, and in extreme cases the blast wave.

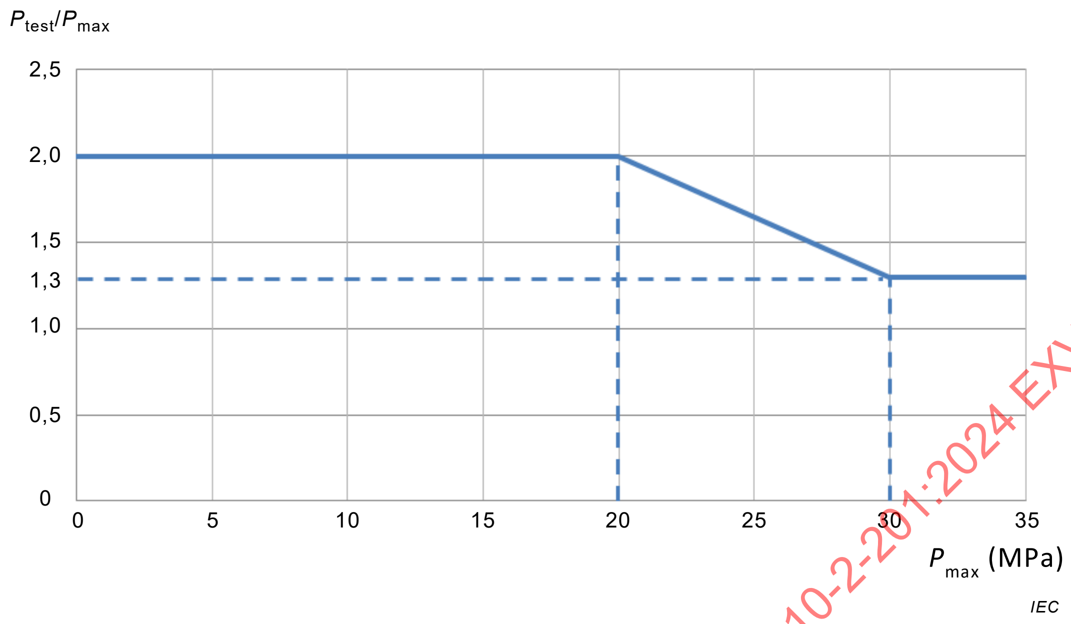


Figure 16 – Ratio between test pressure and maximum working pressure

11.7.3 Leakage from low-pressure parts

Leakage from fluid-containing parts at pressures lower than the levels of 11.7.2 shall not cause a HAZARD.

Conformity is checked by inspection of the RATINGS of parts and, if necessary, by subjecting the parts to a fluid pressure of twice the maximum pressure in NORMAL USE. No leakage shall occur which could cause a HAZARD.

11.7.4 Overpressure safety device

An overpressure safety device shall not operate in NORMAL USE. It shall conform to the following requirements.

a) It shall be connected as close as possible to the fluid-containing parts of the system that it is intended to protect.

b) It shall be installed so as to provide easy access for inspection, maintenance and repair.

c) It shall not be capable of being adjusted without the use of a TOOL.

d) It shall have its discharge opening so located and directed that the released material is not directed towards any person.

e) It shall have its discharge opening so located and directed that operation of the device will not deposit material on parts if that could cause a HAZARD.

f) It shall have adequate discharge capacity to ensure that the pressure cannot exceed the RATED maximum working pressure of the system.

There shall be no shut-off valve between an overpressure safety device and the parts that it is intended to protect.

Conformity is checked by inspection and test.

12 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure

12.1 General

The equipment shall provide protection against the effects of internally generated ultraviolet, ionizing and microwave radiation; laser sources, and sonic and ultrasonic pressure.

Conformity tests are carried out if the equipment is likely to cause such HAZARDS.

12.2 Equipment producing ionizing radiation

12.2.1 Ionizing radiation

12.2.1.1 General

Equipment containing or generating ionizing radiation (from either radioactive sources or X-radiation) shall meet the following requirements.

a) If it is intended to emit radiation, it shall meet the requirements of 12.2.1.2. Alternatively, if it is within the scope of IEC 62598, it shall be tested, classified, and marked according to IEC 62598.

b) If it uses or generates radiation but only emits stray radiation, it shall meet the requirements of 12.2.1.3.

NOTE 1 See IEC 62598, for further information on the requirements for equipment which utilizes ionizing radiation.

NOTE 2 Equipment that emits ionizing radiation is regulated by health authorities in most countries. These regulations often address both the emissions of radiation from the equipment and the cumulative dose of radiation received by the workers and others in the vicinity of the equipment. See the Ionizing Radiation Directive (96/29/EURATOM) or USA 29 CFR 1910.1096 as examples of these regulations.

Conformity is checked by inspection of the IEC 62598 compliance documentation or as specified in 12.2.1.2 or 12.2.1.3, as applicable.

12.2.1.2 Equipment intended to emit radiation

Equipment which contains radioactive substances or that generates x-rays, and is intended to emit ionizing radiation outside the equipment, shall be tested and marked as follows:

The effective dose rate of radiation shall be measured at a constant distance of 50 mm to 1 m from all surfaces of the equipment. The measuring distance shall be between 50 mm and 1 m. If measurements are performed at any distance other than 50 mm, the equivalent effective dose rate at a distance of 50 mm shall be calculated. If the effective dose rate at any easily reached point 50 mm from the outer surface exceeds 5 µSv/h, the equipment shall be marked with all the following markings, if applicable:

a) with symbol 17 of Table 1;

b) for equipment containing one or more radioactive substances, with the abbreviations of the radionuclides;

c) either with the maximum dose rate value at 1 m, or with a dose rate value between 1 µSv/h and 5 µSv/h at the appropriate distance in m.

NOTE Examples of suitable markings are: "2,5 µSv/h at 1 m"; "3 µSv/h at 0,3 m".

Conformity is checked by measuring the amount of radiation in the conditions that will produce maximum radiation. The method of determining the amount of radiation shall be effective over the range of possible radiation energies. Equipment containing X-ray sources is set to produce the maximum possible level of radiation.

12.2.1.3 Equipment not intended to emit radiation

The effective dose rate of unintended stray radiation at any easily reached point 100 mm from the outer surface of the equipment shall not exceed 1 μSv/h.

NOTE Such equipment includes radioactive substances, cathode-ray tubes, X-ray sources, or electron accelerators with voltages exceeding 5 kV.

Conformity is checked by measuring the amount of radiation in the conditions that will produce maximum radiation. The method of determining the amount of radiation shall be effective over the range of possible radiation energies. Equipment containing cathode-ray tubes is tested while displaying a pattern from each beam not exceeding 30 mm × 30 mm or the smallest possible display, whichever is larger. Equipment containing X-ray sources is set to produce the maximum possible level of radiation. Displays are positioned so as to produce maximum radiation.

12.2.2 Accelerated electrons

The equipment shall be so constructed that compartments in which electrons are accelerated by voltages exceeding 5 kV cannot be opened without the use of a TOOL.

Conformity is checked by inspection.

12.3 Optical radiation

Equipment with lamps and lamp systems emitting ultraviolet, visible, or infrared radiation, including light emitting diodes, shall not permit unintentional escape of radiation that could cause a HAZARD.

The radiation sources shall be assessed in accordance with IEC 62471 except for sources considered to be safe (Table 22) or conditionally safe (Table 23). Lamp and lamp systems assessed to be in Risk Groups 1, 2 or 3 of IEC 62471 shall be labelled in accordance with IEC TR 62471-2. If the size or design of the lamp or lamp systems makes labelling impractical, symbol 14 shall be marked on the equipment and the label shall be included in the documentation.

Information on protective measures, restrictions on use, and operating instructions that may be necessary shall be provided, including the applicable conditions of use of Table 23.

NOTE Attention is drawn to the possible existence of additional guidelines or requirements which may be specified by national authorities.

Conformity is checked by inspection and if necessary, by measurement of the optical radiation to determine no hazard exists.

Table 22 – Lamp or lamp systems considered photobiologically safe

Lamp or lamp system
Indicator LEDs
Personal digital device screens
LCD screens
Computer displays
Photographic flash lamps
Interactive whiteboard presentation equipment
Task lighting with tungsten filament lamps, LED lamps, compact fluorescent tubes, or fluorescent tubes with diffusers
Any ‘Exempt Group’ (according to IEC 62471)

Table 23 – Lamp or lamp systems considered photobiologically safe under certain conditions

Lamp or lamp system	Conditions of use
Fluorescent lighting without diffusers over the lamps	Safe at normal illumination levels (~600 lux)
Metal halide/high-pressure mercury flood lights	Safe if the front cover glass is intact and if the lamp is not in line of sight
Desktop projectors	Safe if the beam is not looked into
Low-pressure UVA black-lights	Safe if not in line of sight and hands are not irradiated while holding the black-light

12.4 Microwave radiation

In NORMAL CONDITION and in SINGLE FAULT CONDITION, at any point 50 mm from the equipment, the power density of spurious microwave radiation at frequencies between 1 GHz and 100 GHz shall not exceed 10 W/m^2. This requirement does not apply to parts of the equipment where microwave radiation is propagated intentionally, for example, at waveguide output ports.

For equipment which emits a wireless communication signal, the power density of spurious microwave radiation at frequencies between 1 GHz and 100 GHz shall not exceed 6 W/m^2 measured at a distance of 1 m.

Conformity is checked by test under reference test conditions.

12.5 Sonic and ultrasonic pressure

12.5.1 Sound level

If equipment produces noise at a level which could cause a HAZARD, the manufacturer shall measure the maximum sound pressure level which the equipment can produce (except for sound from alarms and sound from parts remote from the equipment) and shall calculate the maximum sound power level as specified in ISO 3746 or ISO 9614-1.

Installation instructions shall specify how the RESPONSIBLE BODY can ensure that the sound pressure level from equipment, at its point of use after installation, will not reach a value which could cause a HAZARD. These instructions shall identify readily available and practicable protective materials or measures which may be used, including the fitting of noise-reducing baffles or hoods.

NOTE 1 A sound pressure level of 80 dBA above a reference sound pressure of 20 µPa is at present regarded by many authorities as the threshold at which a HAZARD may be caused. Special means, such as the use of protective earpieces, can make a higher level non-hazardous to an OPERATOR.

NOTE 2 The instructions for use should recommend that the sound pressure level be measured or calculated by the RESPONSIBLE BODY both at the OPERATOR'S position in NORMAL USE and at whatever point 1 m from the ENCLOSURE of the equipment has the highest sound pressure level.

Conformity is checked by measuring the maximum A-weighted sound pressure level at the OPERATOR'S position and at bystander positions, and if necessary, calculating the maximum A-weighted sound power level produced by the equipment, as specified in either ISO 3746 or ISO 9614-1. The following conditions apply.

a) During measurement, any part necessary for the correct operation of the equipment and supplied by the manufacturer as an integral part of such equipment, for example, a pump, is fitted and operated as in NORMAL USE.

b) Sound level meters used in the measurement conform either to type 1 of IEC 61672-1 or, if an integrating sound level meter, to type 1 of IEC 61672-2.

c) The test room is semi-reverberant, with a hard reflecting floor. The distance between any wall or any other object and the surface of the equipment is not less than 3 m.

d) The equipment is tested with the combination of load and other operating conditions (for example, pressure, flow, temperature) which creates the maximum sound pressure level.

12.5.2 Ultrasonic pressure

If equipment not intended to emit ultrasound produces ultrasound at a level which could cause a HAZARD, the manufacturer shall measure the maximum ultrasonic pressure level which the equipment can produce. When measured both at the OPERATOR's normal position and at 1 m from the position on the equipment with the highest pressure level, the ultrasonic pressure shall not exceed 110 dB above the reference pressure value of 20 µPa, for frequencies between 20 kHz and 100 kHz.

Conformity is checked by measuring the pressure under reference test conditions.

If equipment intended to emit ultrasound produces ultrasonic pressure at a level which could cause a HAZARD, the manufacturer shall measure the maximum ultrasonic pressure level which the equipment can produce.

The sound pressure shall be measured at the OPERATOR'S normal position and at 1 m from the position on the equipment with the highest pressure level both outside and inside the useful beam.

Outside the useful beam the ultrasonic pressure shall not exceed 110 dB above the reference pressure value of 20 µPa, for frequencies between 20 kHz and 100 kHz.

If inside the useful beam the ultrasonic pressure exceeds 110 dB for frequencies between 20 kHz and 100 kHz, the equipment shall be marked with symbol 14 of Table 1 and the following information shall be in the documentation:

a) the dimensions of the useful beam;

b) the area of the useful beam in which the ultrasonic pressure exceeds 110 dB;

c) the maximum sound pressure value inside the beam area.

Conformity is checked by inspection and measurement of the pressure under reference test conditions.

12.6 Laser sources

Equipment employing laser sources shall meet the requirements of IEC 60825-1.

Conformity is checked as specified in IEC 60825-1.

13 Protection against liberated gases and substances, explosion and implosion

13.1 Poisonous and injurious gases and substances

Equipment shall not liberate dangerous amounts of hazardous substances in NORMAL CONDITION and in SINGLE FAULT CONDITION.

If potentially-hazardous substances are liberated, the OPERATOR shall not be directly exposed to a quantity of the substance that could cause harm.

If NORMAL operation of the equipment requires the discharge of hazardous substances, and if that discharge is intended to be managed by the RESPONSIBLE BODY in accordance with the manufacturer's instructions, then such discharge is not considered to be liberation of hazardous substances.

NOTE Chemical exposure limits and handling and disposal regulations can be found in Occupational Safety and Health (OSHA) publications or national regulatory documentation. Local, national or regional regulations may apply.

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

13.2 Explosion and implosion

13.2.1 Components

If components liable to explode if overheated or overcharged are not provided with a pressure release device, protection for OPERATORS shall be incorporated in the equipment (see 7.7 concerning expelled parts).

Pressure release devices shall be located so that a discharge will not cause danger to OPERATORS. The construction shall be such that no pressure release device is obstructed.

Conformity is checked by inspection.

13.2.2 Batteries and battery charging

Batteries shall not cause explosion or produce a fire HAZARD as a result of excessive charge or discharge, or if a battery is installed with incorrect polarity. If 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.

If an explosion or fire HAZARD could occur through fitting a battery of the wrong type (for example, if a battery with built-in protection is specified) there shall be a warning marking on or near the battery compartment or mounting, and a warning in the manufacturer's instructions. An acceptable marking is symbol 14 of Table 1.

If 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. The marking shall warn against the charging of non-rechargeable batteries and indicate the type of rechargeable battery that can be used with the recharging circuit. An acceptable marking is symbol 14 of Table 1.

The battery compartment shall be designed so that there is no possibility of explosion or fire caused by build-up of flammable gases.

NOTE Also see 11.5.

NOTE 101 For batteries and battery packs the following standards can additionally apply: the IEC 62133 series (battery packs), UL 1642 (lithium batteries), UL 2054 (rechargeable batteries).

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 is made on any single component (except the battery itself) whose failure could lead to such a HAZARD.

For batteries intended to be replaced by an OPERATOR, an attempt is made to install a battery with its polarity reversed. No HAZARD shall arise.

13.2.3 Implosion of cathode ray tubes

Cathode-ray tubes with a maximum face dimension exceeding 160 mm shall be intrinsically protected against the effects of implosion and against mechanical impact, unless an ENCLOSURE provides adequate protection.

A non-intrinsically protected tube shall be provided with an effective protective screen which cannot be removed without the use of a TOOL. If a separate screen of glass is used, it shall not be in contact with the surface of the tube.

A cathode-ray tube is considered to be intrinsically protected with respect to the effects of implosion if no additional protection is necessary when it is correctly mounted.

Conformity for cathode-ray tubes is checked as specified in IEC 60065.

14 Components and subassemblies

14.1 General

If safety is involved, components and subassemblies, such as power supplies and built-in information technology equipment, shall be used in accordance with their specified RATINGS unless a specific exception is made. They shall conform to one of the following:

a) applicable safety requirements of a relevant IEC standard. Conformity with other requirements of the component standard is not required. If necessary for the application, components shall be subjected to the tests of this standard, except that it is not necessary to carry out identical or equivalent tests already performed to check conformity with the component standard;

NOTE 1 For example if components meet the safety requirements of IEC 60950-1 but are RATED for a less severe environment than the applicable environment of 1.4, they also need to meet relevant additional requirements of this standard.

b) the requirements of this standard and, where necessary for the application, any additional applicable safety requirements of the relevant IEC component standard, except that there are no additional requirements for motors and transformers which have passed the applicable tests of 4.4.2.5, 4.4.2.7, 14.2 and 14.6;

c) if there is no relevant IEC standard, the requirements of this standard;

d) applicable safety requirements of a non-IEC standard which 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.

NOTE 2 Tests performed by a recognized testing authority which confirm conformity with applicable safety requirements need not be repeated, even if the tests were performed using a non-IEC standard.

Figure 15 is a flow chart showing methods of conformity verification.

Conformity is checked by inspection and, if necessary, by test.

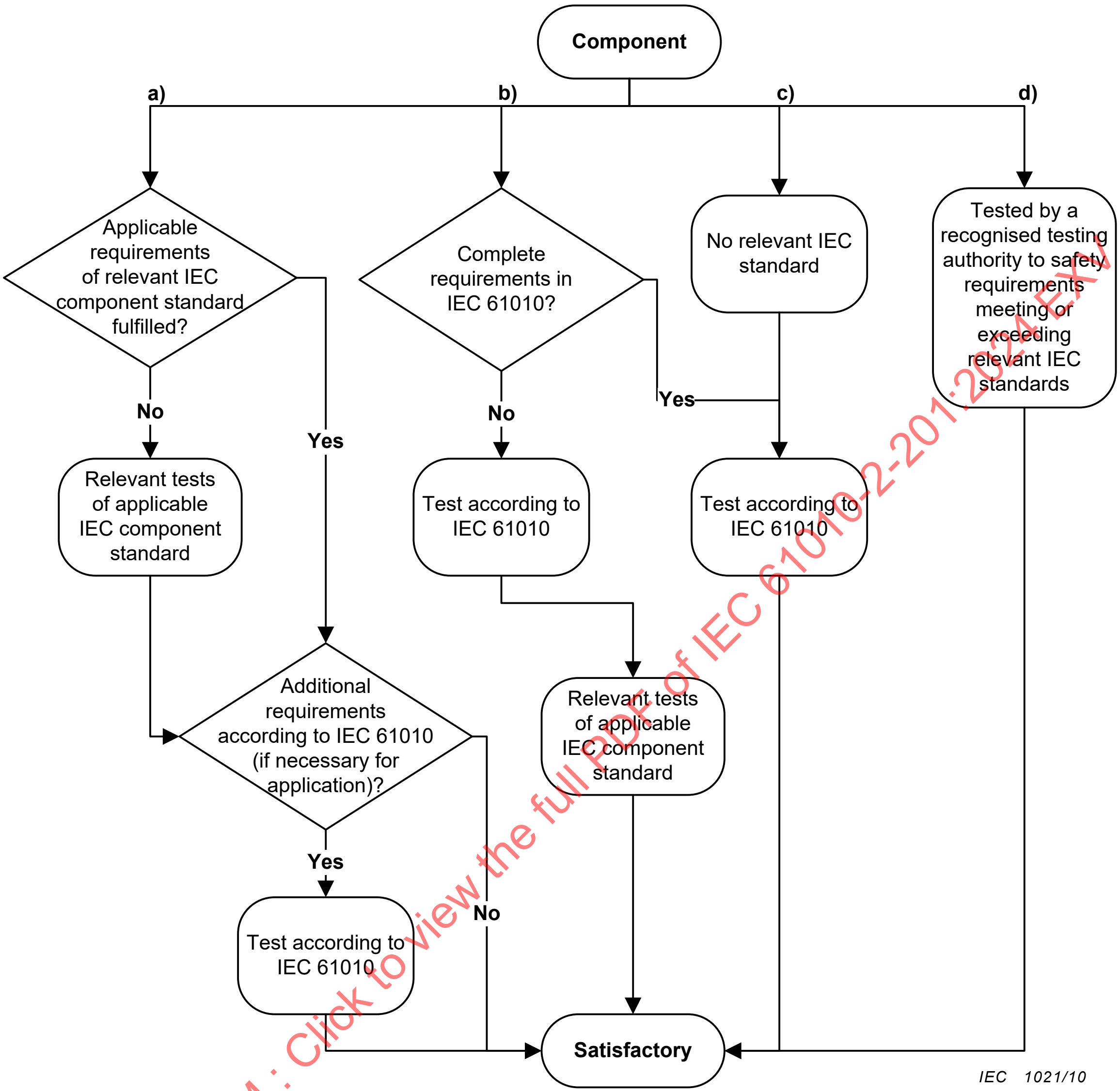


Figure 15 – Flow chart for conformity options 14.1 a), b), c) and d)

14.2 Motors

14.2.1 Motor temperatures

Motors which, when stopped or prevented from starting (see 4.4.2.5), would present an electric shock HAZARD, a temperature HAZARD, or a fire HAZARD shall be protected by an overtemperature or thermal protection device meeting the requirements of 14.3.

Conformity is checked by measurement of the temperature in the SINGLE FAULT CONDITION of 4.4.2.5.

14.2.2 Series excitation motors

If an overspeeding series excitation motor could cause a HAZARD, it shall be connected directly to the devices driven by it.

Conformity is checked by inspection.

14.3 Overtemperature protection devices

Overtemperature protection devices are devices operating in SINGLE FAULT CONDITION. They shall meet all of the following requirements:

a) be constructed so that reliable function is ensured;

b) be RATED to interrupt the maximum voltage and current of the circuit in which they are employed;

c) not operate in NORMAL USE.

If a self-resetting overtemperature protection device is used to prevent a HAZARD in case of failure of a temperature control system (for example a thermostat), the protected part of the equipment shall require intervention before becoming operational again.

Conformity is checked by inspection of the circuit diagram, the data sheet for the overtemperature protection device, and the method in which it is installed in the equipment, and by the following tests, with the equipment operated in SINGLE FAULT CONDITION (see 4.4). The number of operations is as follows:

1) *self-resetting overtemperature protection devices are caused to operate 200 times;*
2) *non-self-resetting overtemperature protection devices, except thermal fuses, are reset after each operation and thus caused to operate 10 times;*
3) *non-resetting overtemperature protection devices are caused to operate once.*

NOTE Forced cooling and resting periods may be introduced to prevent damage to the equipment.

During the test, resetting overtemperature protection devices shall operate each time the SINGLE FAULT CONDITION is applied and non-resetting overtemperature protection devices shall operate once. After the test, resetting overtemperature protection devices shall show no sign of damage which could prevent their operation in a further SINGLE FAULT CONDITION.

14.4 Fuse holders

If a fuse is intended to be replaced by an OPERATOR the fuse holder shall not permit HAZARDOUS LIVE parts to be ACCESSIBLE during fuse replacement.

Conformity is checked by testing with the jointed test finger (see Figure B.2) applied without force.

14.5 MAINS voltage selection devices

Devices shall be constructed so that a change from one voltage or one type of supply to another cannot occur accidentally. See 5.1.3 d) for marking requirements.

Conformity is checked by inspection and manual test.

14.6 MAINS transformers tested outside equipment

If environmental conditions could affect the test results, MAINS transformers tested outside the equipment (see 4.4.2.7) shall be tested in the same conditions as exist inside the equipment.

Conformity is checked by the short-circuit and overload tests specified in 4.4.2.7, followed by the test of 4.4.4.1 b) and c). If there is any doubt whether a transformer would pass the other tests specified in 4.4.4 and 10.2 when installed in the equipment, the tests are repeated with the transformer installed in the equipment.

14.7 Printed wiring boards

Printed wiring boards shall be made of material with a flammability classification of V-1 or better of IEC 60695-11-10.

This requirement does not apply to printed wiring boards which contain only limited-energy circuits meeting the requirements of 9.4.

Conformity of the flammability RATING is checked by inspection of data on the materials. Alternatively, conformity is checked by performing the vertical burn tests of IEC 60695-11-10 on three samples of the relevant parts. The samples may be complete boards, sections of the boards or specimens as specified in IEC 60695-11-10.

14.8 Circuits used to limit TRANSIENT OVERVOLTAGES

Any overvoltage limiting circuit that forms part of the equipment shall have adequate strength to limit likely TRANSIENT OVERVOLTAGES.

Table 21 – Impulse voltages for OVERVOLTAGECATEGORY II

Line-to-neutral MAINS voltage V r.m.s. or d.c.	Impulse voltage V
≤50	500
>50 ≤ 100	800
>100 ≤ 150	1 500
>150 ≤ 300	2 500
>300 ≤ 600	4 000
>600 ≤ 1 000	6 000

Conformity is checked by the following test: 5 positive and 5 negative impulses are applied with the applicable impulse voltage of Table 21, spaced up to 1 min apart, from a hybrid impulse generator (see IEC 61180-1). The generator produces an open-circuit voltage waveform of 1,2/50 μs, a short-circuit current waveform of 8/20 μs, with an output impedance (peak open-circuit voltage divided by peak short-circuit current) of 12 Ω (resistance may be added in series if needed to raise the impedance). The impulse is applied while the circuit is operating under conditions of NORMAL USE, in combination with the MAINS supply. The MAINS voltage is the maximum RATED MAINS voltage.

The test voltage is applied between each pair of MAINS supply TERMINALS of the equipment where overvoltage limiting circuits are present.

The overvoltage limiting circuit components shall not ignite or heat other materials to their self-ignition points. The overvoltage limiting circuit shall safely suppress the impulse and continue to function properly after the test.

NOTE The impulse voltage and generator output impedance specified above apply to equipment with a RATING for OVERVOLTAGE CATEGORY II. Conformity for equipment with a rating for OVERVOLTAGE CATEGORIES III and IV is specified in Clause K.4.

14.101 Components bridging insulation

14.101.1 Capacitors

A capacitor connected between two line conductors in a MAINS CIRCUIT, or between one line conductor and the neutral conductor shall comply with subclass X1 or X2 of IEC 60384-14.

A capacitor between the MAINS CIRCUIT and protective earth shall comply with subclass Y1, Y2 or Y4 of IEC 60384-14.

A capacitor bridging DOUBLE INSULATION or REINFORCED INSULATION in the control equipment shall comply with subclass Y1 or Y2 of IEC 60384-14.

In all cases a capacitor shall be used in accordance with its RATING.

These requirements do not apply to a capacitor connected between a hazardous voltage secondary circuit and protective earth, where only BASIC INSULATION is required.

Capacitors in conformity with IEC 60384-14 and approved by a recognized testing authority may be removed from the circuit for the high-voltage TYPE TEST.

Removal from the circuit is allowed, when the value of the required voltage test is higher than the rated value of the capacitor.

Compliance is checked by inspection.

14.101.2 Surge suppressors

Any surge suppressor shall, in accordance with 14.1, be suitable for the application, taking into account the impulse voltage test of 14.8.

- for OVERVOLTAGE CATEGORY II selection, AC MAINS voltage and OVERVOLTAGE CATEGORY, see Table 21; or
- for OVERVOLTAGE CATEGORY III or IV, see Clause K.4.

Where a surge suppressor(s) is bridging an isolation, an overcurrent protection shall be provided in series with the surge suppressor(s).

Where a single surge suppressor is used in the MAINS CIRCUIT, it shall be a voltage dependent resistor (VDR, also known as metal oxide varistor (MOV)).

NOTE 1 MAINS CIRCUIT can be both supply circuit and control circuits such as HAZARDOUS LIVE circuits connected to relay terminals.

It is permitted to use any type of single surge suppressor component in secondary circuits.

NOTE 2 It is not a requirement of this document to comply with any particular component standard for surge suppressors. Component requirements are given in IEC 61643 series of standards:

- IEC 61643-21 (surge suppressors in telecommunications application),
- IEC 61643-311 (gas discharge tubes),
- IEC 61643-321 (avalanche breakdown diodes),
- IEC 61643-331 (metal oxide varistors).

NOTE 3 Where the surge suppressor is not used for primary protection, see IEC 61051-2.

Compliance is checked by inspection.

14.102 Switching devices

14.102.1 General

This subclause is only applicable to switching devices with a RISK of fire or shock.

Switching devices controlling outputs shall be used within their RATINGS, according to IEC 60947-5-1 or IEC 61810-1, or equipment utilizing them shall be subjected to the overload and endurance tests specified in 14.102.2 and 14.102.3, respectively.

The closed circuit test voltage shall be 100 % to 110 % of the test voltage specified in Table 102, unless otherwise specified for the overload test.

Table 102 – Overload and endurance test voltages

	Voltage rating of switching device[a] V (a.c./d.c.)						
	110 to 120	**220 to 240**	**254 to 277**	**380 to 415**	**440 to 480**	**560 to 600**	**660 to 690**
Test voltage	120	240	277	415	480	600	690

NOTE This table is derived from IEC 61810-1:2015, Table D.5.

[a] If the rating does not fall within any of the indicated voltage ranges, it shall be tested at its maximum rated (nominal or operating) voltage.

Switching devices intended for control of single-phase motors with ratings greater than 2 horsepower (or the equivalent FLA/LRA ratings) or 3-phase motors shall be evaluated in accordance with IEC 60947-4-1 or IEC 60947-4-2 as applicable.

NOTE 1 Variable speed drive control is covered by the IEC 61800 series.

Switching devices intended for control loads other than the types indicated above or in Table 103 and Table 104 shall be tested in accordance with IEC 61810-1:2015, Annex D.

Switching devices may be tested with the specific intended load device if the load is integral to the assembly under evaluation or specified by the manufacturer and model number in the instructions.

For output devices with multiple ratings, a sufficient number of tests shall be conducted to cover the conditions of maximum voltage, maximum current, maximum power, maximum rise time ($T_{0,95}$), and minimum power factor ratings. The intent is to ensure the worst-case operating condition combination is tested.

NOTE 2 Derived from UL 508:2018, 214.2.

Outputs adjacent to the output under test shall be connected to the source polarity not likely to strike to protective earth, unless all outputs are intended to connect to the same source.

If the switching device is approved to an appropriate component standard, it may be exempted from these tests.

Conformity, pass/fail, is determined by test completion without electrical, dielectrical or mechanical breakdown of the equipment.

The dielectric test is based on the values required in 6.7 for basic isolation.

Contacts shall be monitored to detect break or make malfunctions, or both, as well as unintended bridging. Temporary malfunctions are not permitted. A temporary malfunction is an event that will self-correct, so that it does not repeat over the following test cycle. One or more failures result in failure of the endurance test.

NOTE 3 Derived from IEC 61810-1:2015, 11.1 and 11.3.

Solid-state output switching devices shall be required to establish an ON-state, to commutate, to carry designated levels of load and, if applicable, overload currents, and to establish and sustain an OFF-state condition without failure or any type of damage.

NOTE 4 Derived from IEC 62314:2006, 8.2.

14.102.2 Overload test

Switching devices shall close and open a test circuit having the current, voltage, and power factor values given in Table 103. Fifty cycles, each consisting of 1 closing and 1 opening, shall be completed using a timing of 1 s ON, 9 s OFF. After completion of the 50 cycles, the equipment shall be subjected to the endurance test in 14.102.3.

Table 103 – Overload test circuit values

Intended device application	Test current A	Power factor rise time ($T_{0,95}$)[d] ms
a.c. resistance	1,5 times device rated value[b]	1 000
d.c. resistance	1,5 times device rated value[b]	≤ 1
a.c. general use	1,5 times device rated value[b]	750 to 800
d.c. general use	1,5 times device rated value[b]	≤ 1
a.c. pilot duty [AC-15][a]	[e f]	≤ 350
d.c. pilot duty [DC-13][a]	[e f]	6 × P [c] ≤ 300

NOTE This table is derived from IEC 61810-1:2015, Table B.1. and Table D.1.

[a] Load utilization category as defined in IEC 60947-1:2020, Annex A or IEC 61810-1:2015, and given in brackets, is provided for reference only.

[b] Voltage shall be in accordance with Table 102.

[c] The value "6 × P" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where 6 × P = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value. [SOURCE: Footnotes to IEC 60947-5-1:2016, Table 4 and IEC 61810-1:2015, Table B.1.]

[d] Time to reach 95 % of the steady-state current in ms.

[e] Intended load consists of relay coil, contactor coil, or solenoid valve.

[f] Load shall be configured in accordance with the endurance test with the voltage then increased to 1,1 times the endurance test voltage.

For switching devices that are intended for control of a specific intended load device the overload test shall be conducted with the voltage increased to 1,1 times the test voltage for the endurance. When tested with specific motors, the overload test shall be conducted with the motor in the locked rotor condition.

Conformity is checked by the method in 14.102.1.

NOTE If the endurance test is to be performed, it is not necessary to do the conformity check at this point.

14.102.3 Endurance test

After completion of the overload test in 14.102.2, the switching device is to close and open a test circuit having the cycle rate, number of cycles, current, voltage, and power factor rise time ($T_{0,95}$) values given in Table 104.

It is not necessary for the endurance test to be conducted on solid-state output devices rated for general use or resistance applications only.

Switching device outputs rated with a contact code designation for pilot duty shall be tested with both the maximum operational voltage (U_e) and the maximum operation current (I_e) correlating with the designation in IEC 61810-1:2015, Table B.4.

Table 104 – Endurance test circuit values

Intended device application[b]	Test current A	Power factor rise time ($T_{0,95}$)[d] ms	Number of cycles	Test cycle time s	
				On	**Off[f]**
a.c. general use	Rated current	750 to 800	6 000	1	9
a.c. resistive	Rated current	1 000	6000	1	9
d.c. general use or resistive	Rated current	≤ 1	6 000	1	9
a.c. pilot duty[e] [AC-15][a]	Rated current	≤ 350	6 000	1[g]	9[g]
d.c. pilot duty[e] [DC-13][a]	Rated current	6 × P [c] ≤ 300	6 000	1[g]	9[g]

NOTE This table is derived from IEC 61810-1:2015, Table B.2. and Table D.2.

[a] Load utilization category as defined in IEC 60947-1:2020, Annex A or IEC 61810-1:2015, Annex B, given in brackets, is provided for reference only.

[b] Voltage shall be in accordance with Table 102.

[c] The value "6 × P" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where 6 × P = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value. [SOURCE: Footnotes to IEC 60947-5-1:2016, Table 4 and IEC 61810-1:2015, Table B.1.]

[d] Time to reach 95 % of the steady-state current in ms.

[e] Intended load consists of relay coil, contactor coil, or solenoid valve.

[f] A shorter off time may be used if agreeable to all concerned.

[g] The first 1 000 cycles shall be at a rate of 1 cycle per second except that the first 10 to 12 cycles shall be as fast as possible.

For switching devices that are intended for control of a specific intended load, the endurance test shall be conducted with the cycle rate and number of cycles determined from Table 104 or IEC 61810-1:2015, Annex D, based on the type of load device. When tested with specific motors, the endurance test shall be conducted with the motor in the full (maximum) load condition.

The test specified in 6.7.2.2.1 between the switching output circuit(s) and other circuits shall immediately follow the endurance test or the overload test when conducted alone.

Conformity is checked by the method in 14.102.1.

15 Protection by interlocks

IEC 61010-1:2010, Clause 15 does not apply.

16 HAZARDS resulting from application

16.1 REASONABLY FORESEEABLE MISUSE

No HAZARDS shall arise if adjustments, knobs, or other software-based or hardware-based controls are set in a way not intended, and not described in the instructions. Other possible cases of REASONABLY FORESEEABLE MISUSE that are not addressed by specific requirements in this standard shall be addressed by RISK assessment (see Clause 17).

Conformity is checked by inspection and by evaluation of the RISK assessment documentation.

16.2 Ergonomic aspects

If the following factors could give rise to a HAZARD, a RISK assessment shall be documented, taking into account at least the following aspects:

a) limitation of body dimensions;

b) displays and indicators;

c) accessibility and conventions of controls;

d) arrangements of TERMINALS.

Conformity is checked by inspection and by evaluation of the RISK assessment documentation.

NOTE RISK assessment procedures for ergonomics may be found in EN 894-2, EN 894-3, ISO 9241, SEMI S8, and other documents. Not all of the requirements in these documents will be applicable to equipment within the scope of this standard.

17 RISK assessment

If examination of the equipment shows that HAZARDS not fully addressed in Clauses 6 to 16 (see 1.2.1) might arise, then RISK assessment is required. It shall be carried out and documented to achieve at least a TOLERABLE RISK by an iterative process covering the following.

a) RISK analysis

RISK analysis is the process to identify HAZARDS and to estimate the RISKS based on the use of available information.

b) RISK evaluation

Each RISK analysis requires a plan to evaluate the estimated severity and likelihood of a RISK, and to judge the acceptability of the resulting RISK level.

c) RISK reduction

If the initial RISK level is not acceptable, steps shall be taken to reduce the RISK. The process of RISK analysis and RISK evaluation shall then be repeated, including checking that no new RISKS have been introduced.

RISKS remaining after a RISK assessment shall be identified in the instructions for the RESPONSIBLE BODY. Adequate information about how to mitigate these RISKS shall be given (see 5.4.1 e)).

In selecting the most appropriate methods of RISK reduction, the manufacturer shall apply the following principles, in the order given:

1) eliminate or reduce RISKS as far as possible (an inherently safe design and construction);

2) take the necessary protective measures in relation to RISKS that cannot be eliminated;

3) inform users of the residual RISKS due to any shortcomings of the protective measures adopted, indicate whether any particular training is required, and specify any need to provide personal protective equipment.

NOTE One RISK assessment procedure is outlined in Annex J. Other RISK assessment procedures are contained in ISO 14971, SEMI S10-1296, IEC 61508, ISO 14121-1, and ANSI B11.TR3. Other established procedures which implement similar steps can also be used.

Conformity is checked by evaluation of the RISK assessment documentation to ensure that the RISKS have been eliminated or that only TOLERABLE RISKS remain.

Annex A
(normative)

Measuring circuits for touch current
(see 6.3)

NOTE This annex is based on IEC 60990, which specifies procedures for measuring touch-current, and also specifies the characteristics for test voltmeters.

A.1 Measuring circuit for a.c. with frequencies up to 1 MHz and for d.c.

The current is measured using the circuit of Figure A.1. The current is calculated from:

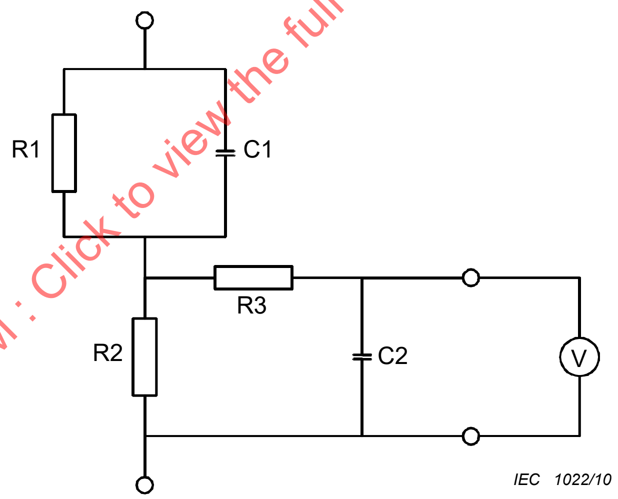
$$I = \frac{U}{500}$$

where

I is the current, in amperes;

U is the voltage, in volts, indicated by the voltmeter.

This circuit represents the impedance of the body and compensates for the change of physiological response of the body with frequency.



R1 = 1 500 Ω with a relative tolerance of ±5 %

R2 = 500 Ω with a relative tolerance of ±5 %

R3 = 10 kΩ with a relative tolerance of ±5 %

C1 = 0,22 μF with a relative tolerance of ±10 %

C2 = 0,022 μF with a relative tolerance of ±10 %

Figure A.1 – Measuring circuit for a.c. with frequencies up to 1 MHz and for d.c.

A.2 Measuring circuits for sinusoidal a.c. with frequencies up to 100 Hz and for d.c.

If the frequency does not exceed 100 Hz, the current may be measured using either of the circuits of Figure A.2. When using the voltmeter, the current is calculated from:

$$I = \frac{U}{2\ 000}$$

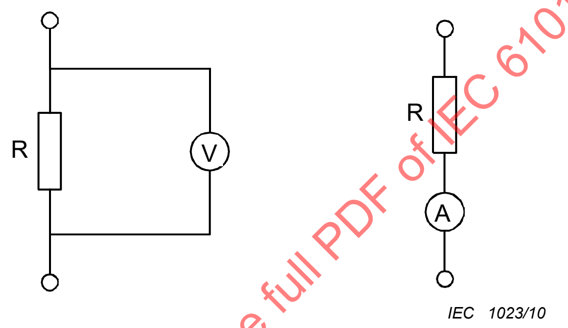
where

I is the current in amperes;

U is the voltage, in volts, indicated by the voltmeter.

The circuit represents the impedance of the body for frequencies not exceeding 100 Hz.

NOTE The value 2 000 Ω includes the impedance of the measuring instrument.



R = 2 000 Ω with a relative tolerance of ±5 %

Figure A.2 – Measuring circuits for sinusoidal a.c. with frequencies up to 100 Hz and for d.c.

A.3 Current measuring circuit for electrical burns at high frequencies

The current is measured using the circuit of Figure A.3. The current is calculated from:

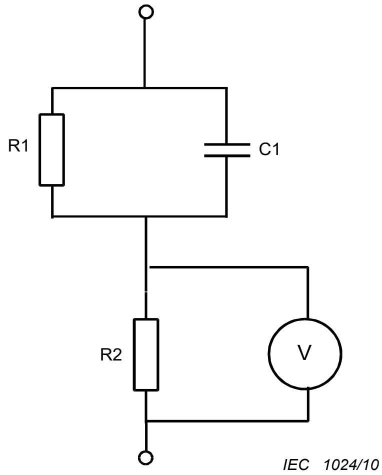
$$I = \frac{U}{500}$$

where

I is the current in amperes;

U is the voltage, in volts, indicated by the voltmeter.

This circuit compensates for the effects of high frequency on the physiological response of the body.



R1 = 1 500 Ω with a relative tolerance of ±5 %

R2 = 500 Ω with a relative tolerance of ±5 %

C1 = 0,22 μF with a relative tolerance of ±10 %

Figure A.3 – Current measuring circuit for electrical burns

A.4 Current measuring circuit for WET LOCATION

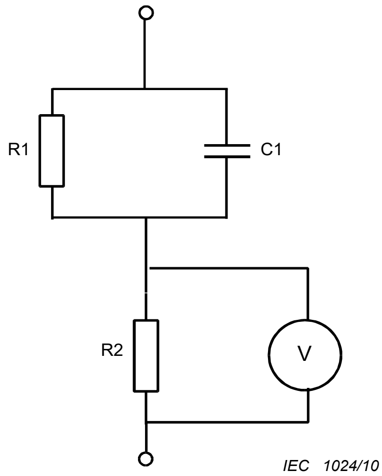
For WET LOCATION the current is measured using the circuit of Figure A.4. The current is calculated from:

$$I = \frac{U}{500}$$

where

I is the current in amperes;

U is the voltage, in volts, indicated by the voltmeter.



R1 = 375 Ω with a relative tolerance of ±5 %

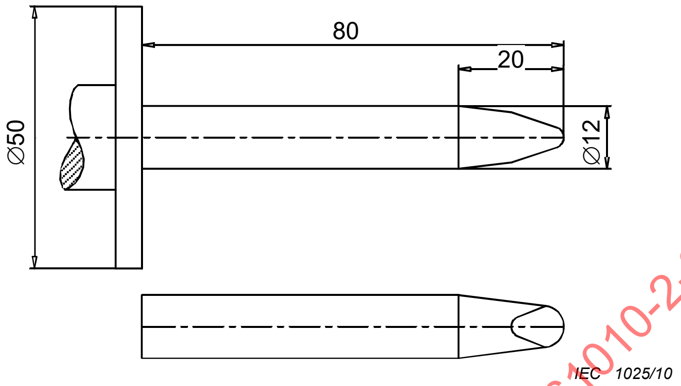
R2 = 500 Ω with a relative tolerance of ±5 %

C1 = 0,22 μF with a relative tolerance of ±10 %

Figure A.4 – Current measuring circuit for wet contact

Annex B
(normative)

Standard test fingers
(see 6.2)

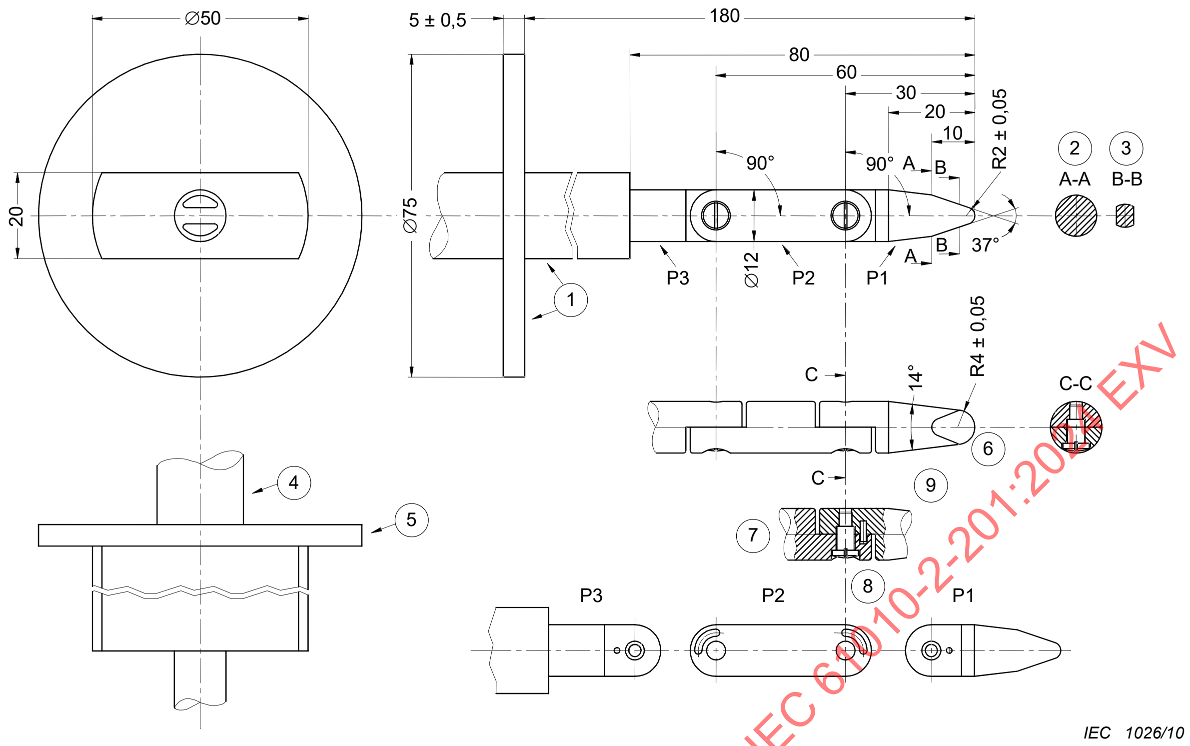


For tolerances and dimensions of the fingertip, see Figure B.2.

Dimensions in millimetres

NOTE This test finger is the same as test probe 11 of IEC 61032, Figure 7

Figure B.1 – Rigid test finger



Key

1 insulating material

2 section AA

3 section BB

4 handle

5 stop plate

6 spherical

7 detail x (example)

8 side view

9 chamfer all edges

Dimensions in millimetres

Tolerances on dimensions without specific tolerance:

– on angles: $^{0}_{-10'}$

– on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$ mm

over 25 mm: ±0,2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of $(90\,^{+10}_{0})$°, but in one plane only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design shall ensure a $(90\,^{+10}_{0})$° bending angle.

NOTE This test finger is the same as test probe B of IEC 61032, Figure 2

Figure B.2 – Jointed test finger

Annex C
(normative)

Measurement of CLEARANCES and CREEPAGE DISTANCES

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are indicated in the following examples 1 to 11 (see Figure C.1). These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

a) where the distance across a groove is equal to or larger than *X* (see Table C.1), the CREEPAGE DISTANCE is measured along the contours of the groove (see example 2);

b) any recess is assumed to be bridged with an insulating link having a length equal to *X* and being placed in the least favourable position (see example 3);

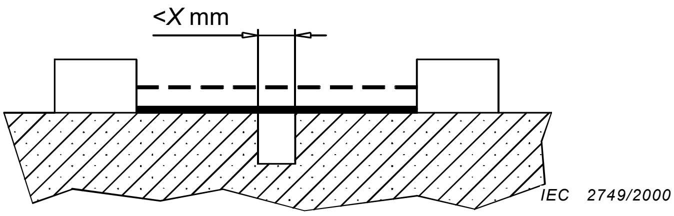
c) CLEARANCES and CREEPAGE DISTANCES measured between parts which can assume different positions in relation to each other are measured when these parts are in their least favourable position.

In the following examples dimension *X* has the value given in Table C.1 depending on the POLLUTION DEGREE.

Table C.1 – Dimensions of X

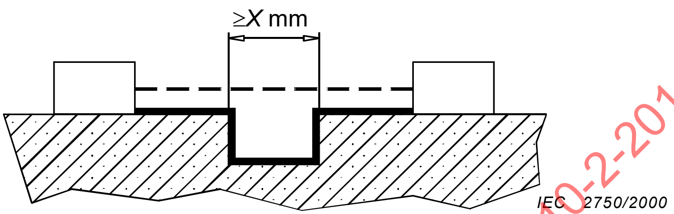
POLLUTION DEGREE	Dimension *X* mm
1	0,25
2	1,0
3	1,5

If the associated CLEARANCE is less than 3 mm, the dimension *X* in Table C.1 may be reduced to one-third of this CLEARANCE.



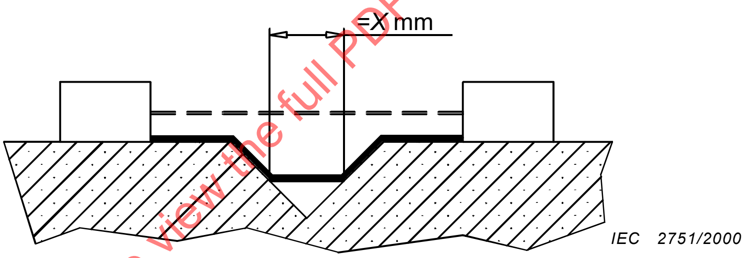
EXAMPLE 1 The path includes a parallel- or converging-sided groove of any depth with a width less than *X*.

The CLEARANCE and the CREEPAGE DISTANCE are measured directly across the groove as shown.



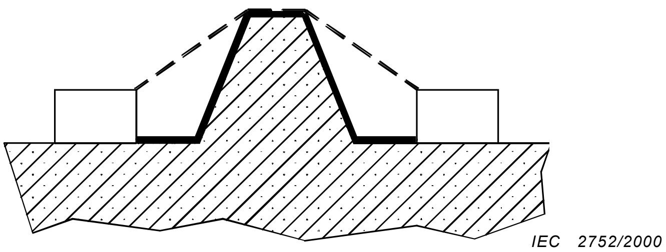
EXAMPLE 2 The path includes a parallel-sided groove of any depth and equal to or more than *X*.

The CLEARANCE is the "line-of-sight" distance. The CREEPAGE DISTANCE follows the contour of the groove.



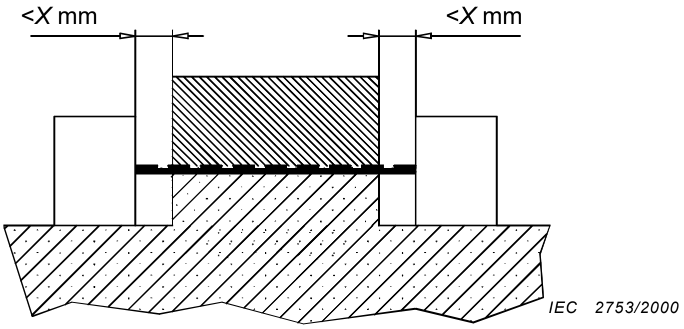
EXAMPLE 3 The path includes a V-shaped groove with a width greater than *X*.

The CLEARANCE is the "line-of-sight" distance. The CREEPAGE DISTANCE follows the contour of the groove but "short-circuits" the bottom of the groove by *X* link.



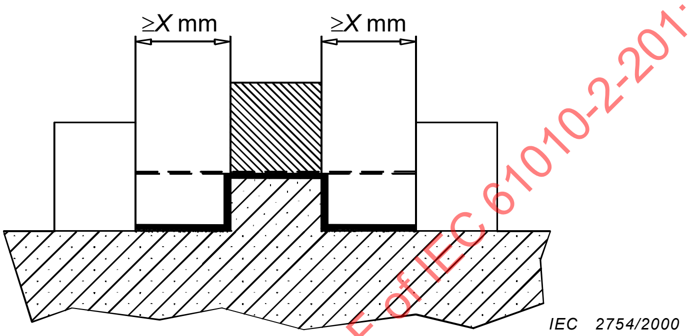
EXAMPLE 4 The path includes a rib.

The CLEARANCE is the shortest direct air path over the top of the rib. The CREEPAGE DISTANCE follows the contour of the rib.



EXAMPLE 5 The path includes an uncemented joint with grooves less than *X* wide on each side.

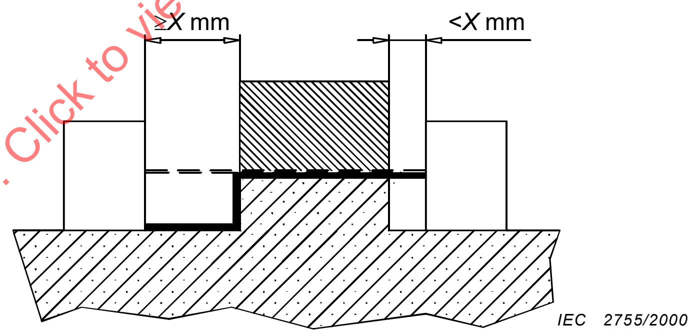
The CLEARANCE and the CREEPAGE DISTANCE path is the "line-of-sight" distance shown.



EXAMPLE 6 The path includes an uncemented joint with grooves equal to, or more than, *X*.

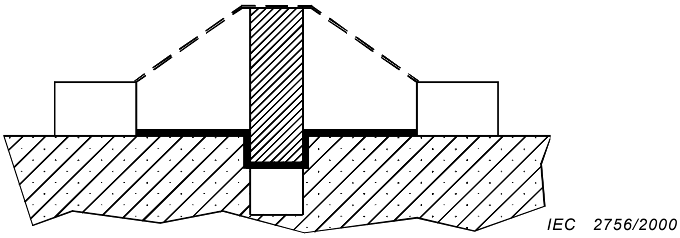
The CLEARANCE is the "line-of-sight" distance.

The CREEPAGE DISTANCE follows the contour of the grooves.



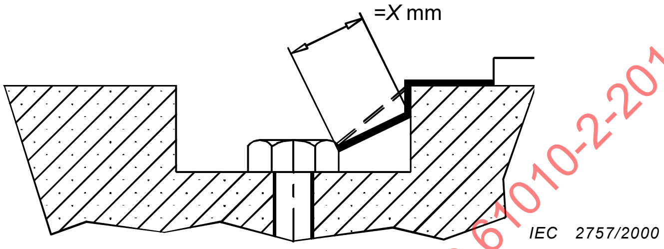
EXAMPLE 7 The path includes an uncemented joint with a groove on one side less than *X* wide and the groove on the other side equal to, or more than, *X* wide.

The CLEARANCE and the CREEPAGE DISTANCE are as shown.

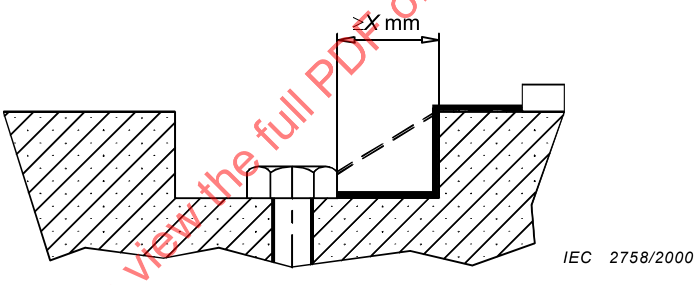


EXAMPLE 8 The CREEPAGE DISTANCE through the uncemented joint is less than the CREEPAGE DISTANCE over the barrier.

The CLEARANCE is the shortest direct air path over the top of the barrier.

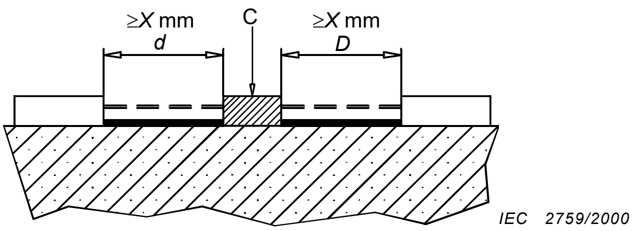


EXAMPLE 9 The gap between the head of the screw and the wall of the recess too narrow to be taken into account.



EXAMPLE 10 The gap between the head of the screw and the wall of the recess wide enough to be taken into account.

Measurement of the CREEPAGE DISTANCE is from screw to wall when the distance is equal to *X*.



EXAMPLE 11 C = floating part

The CLEARANCE is the distance *d* + *D*. The CREEPAGE DISTANCE is also *d* + *D*.

——— CREEPAGE DISTANCE

– – – – CLEARANCE

Figure C.1 – Examples of methods of measuring CLEARANCES and CREEPAGE DISTANCES

Annex D
(normative)

Parts between which insulation requirements are specified
(see 6.4 and 6.5.3)

The following symbols are used in Figures D.1 to D.3 to indicate:

a) Requirements:

B BASIC INSULATION is required

D DOUBLE INSULATION or REINFORCED INSULATION is required

b) Circuits and parts:

A ACCESSIBLE part, not bonded to the PROTECTIVE CONDUCTOR TERMINAL

H circuit that is HAZARDOUS LIVE in NORMAL CONDITION

R impedance meeting the requirements of 6.4.4

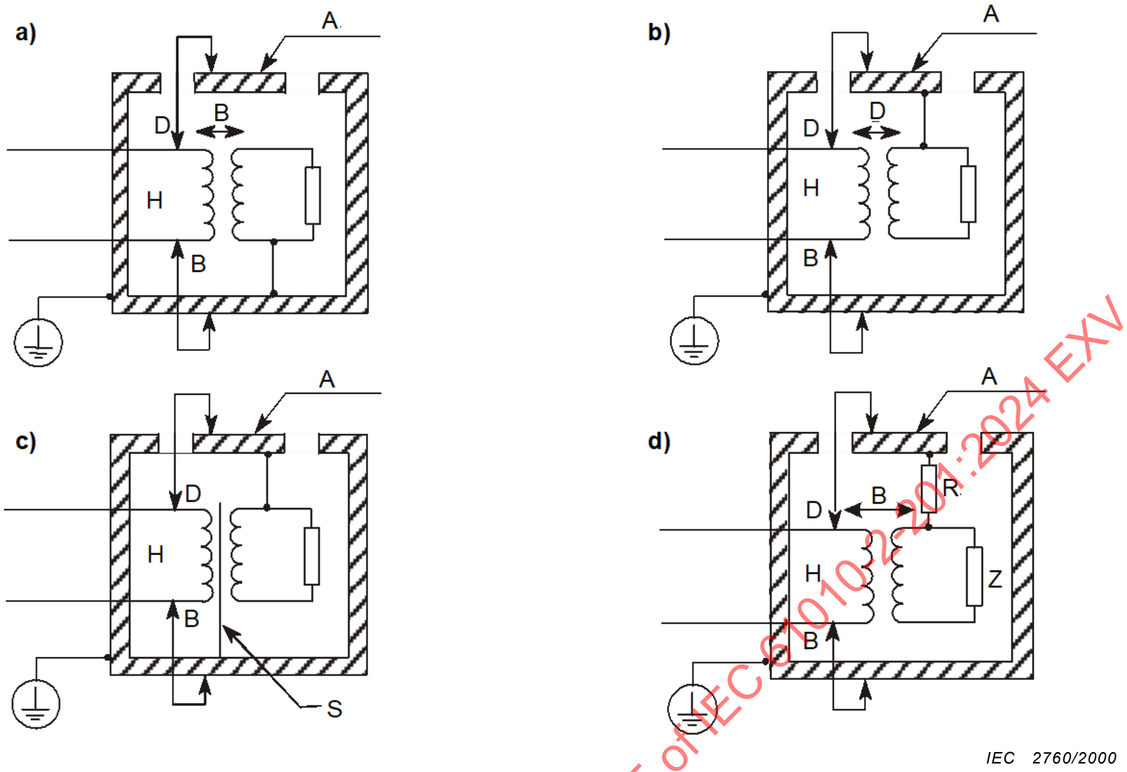
S protective screen

T_A ACCESSIBLE external TERMINAL (not exceeding the values of 6.3.1 in NORMAL CONDITION)

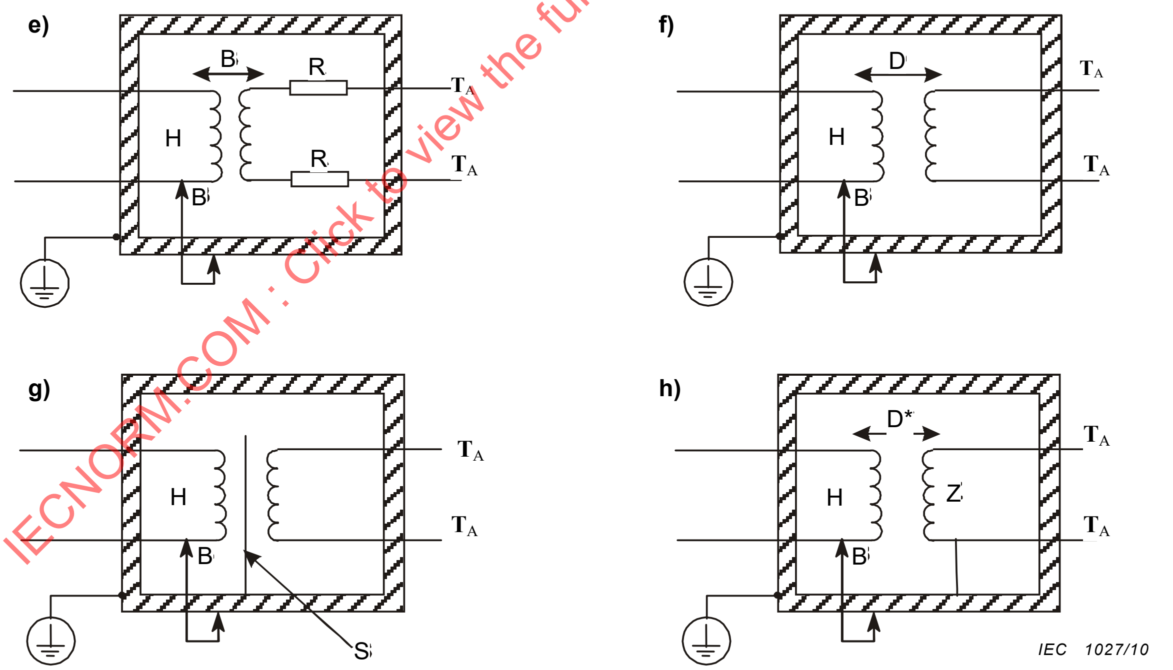
T_N TERMINAL (which may exceed the values of 6.3.1 in NORMAL CONDITION, and therefore shall not be ACCESSIBLE)

Z impedance of secondary circuit

The secondary circuits shown may also be regarded merely as parts.

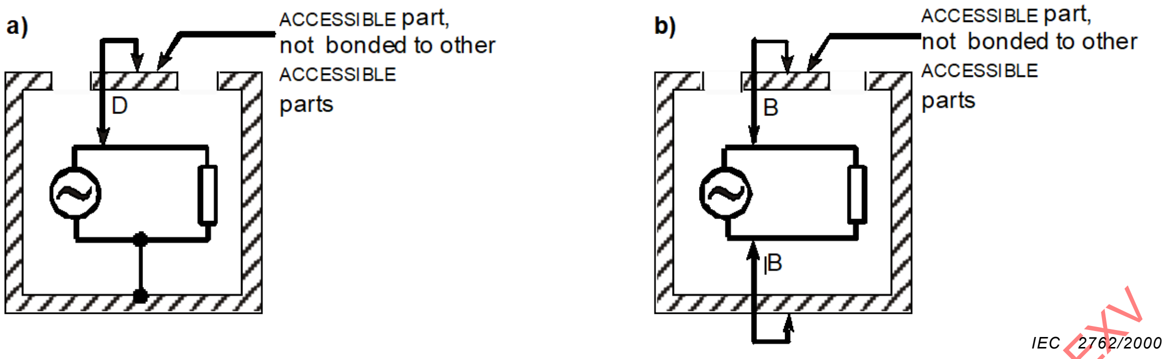


Figures D.1a) to d) – Protection between HAZARDOUS LIVE circuits and ACCESSIBLE parts

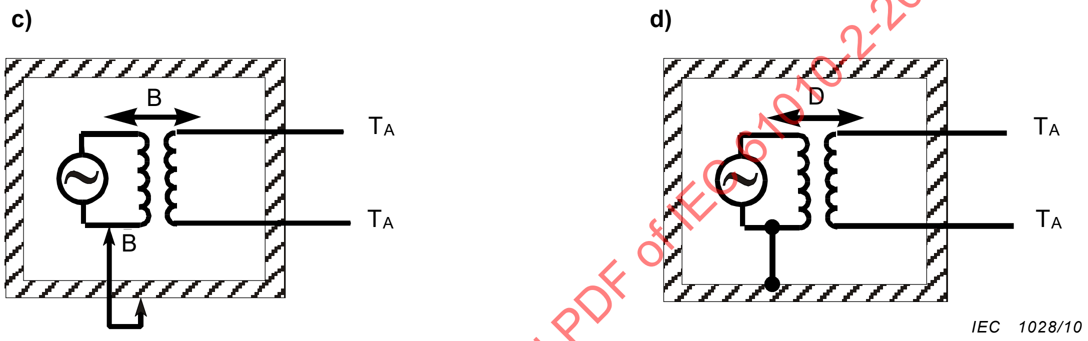


D* may be B if Z is sufficiently low

Figures D.1e) to h) – Protection between HAZARDOUS LIVE circuits and circuits with ACCESSIBLE external TERMINALS



Figures D.2 a) and D.2 b) – Protection between a HAZARDOUS LIVE internal circuit and an ACCESSIBLE part which is not bonded to other ACCESSIBLE parts



Figures D.2 c) and D.2 d) – Protection between a HAZARDOUS LIVE primary circuit and circuits which have ACCESSIBLE external TERMINALS

NOTE 1 Other means of protection are also possible for the circuits shown in Figures D.2 c) and D.2 d), such as protective screening, PROTECTIVE BONDING of circuits (see 6.5.2) and PROTECTIVE IMPEDANCE (see 6.5.4).

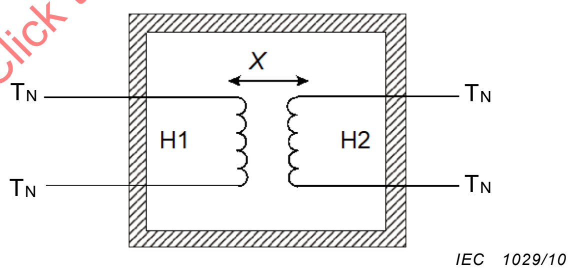


Figure D.3 – Protection of external ACCESSIBLE TERMINALS of two HAZARDOUS LIVE circuits

NOTE 2 The requirement for insulation between an ACCESSIBLE part not bonded to the PROTECTIVE CONDUCTOR TERMINAL and either of the two HAZARDOUS LIVE circuits is as shown in D.1 a) to D.1 d).

The requirement for the insulation between H1 and H2 (*X)* is the most severe of the following:

B BASIC INSULATION – if H1 and H2 are both connected, the insulation requirement is based on the highest RATED WORKING VOLTAGE that stresses the insulation between the circuits;

D DOUBLE INSULATION or REINFORCED INSULATION – if H1 is connected and the TERMINALS of H2 are ACCESSIBLE for connection purposes, the insulation requirement is based on the highest RATED WORKING VOLTAGE that stresses the insulation of H1;

D DOUBLE INSULATION or REINFORCED INSULATION – if H2 is connected and the TERMINALS of H1 are ACCESSIBLE for connection purposes, the insulation requirement is based on the highest RATED WORKING VOLTAGE that stresses the insulation of H2.

Annex E
(informative)

Guideline for reduction of POLLUTION DEGREES

The micro-environment inside the equipment is determined by the environmental conditions to which the equipment is exposed during operation, installation, maintenance, and any POLLUTION generated by the equipment itself as well as by the effectiveness of applied sealing measures.

Equipment can be divided into environmental situations as depicted in Table E.1.

Table E.1 – Environmental situations

Environmental situation	Equipment operated in ...	Installation or maintenance of equipment in ...
A	controlled environment[a]	controlled environment
B	uncontrolled environment	controlled environment or equipment is not opened during installation or maintenance
C	uncontrolled environment	uncontrolled environment

[a] A controlled environment is an environment having the conditions of IEC 61010-1:2010, 1.4.1 c) and d).

NOTE The environmental situation of Table E.1 provides a systematic classification of the environments to which the equipment is exposed and whether the equipment can be opened for installation and maintenance purposes.

Reduction of the POLLUTION DEGREE of the micro-environment may be achieved by the methods of Table E.2. It is possible that the POLLUTION DEGREE cannot be reduced when the equipment is subject to condensation or it produces pollutants itself.

Table E.2 – Reduction of POLLUTION DEGREES (PD)

Additional protection	Original POLLUTION DEGREE						
	2			3		4	
	Environmental situation (Table E.1)						
	A	B	C	B	C	B	C
	Pollution degree with additional protection						
ENCLOSURE **IPx4**	--	--	--	--	--	--	--
ENCLOSURE **IPx5, IPx6**	1	--	--	--	--	--	--
ENCLOSURE **IPx7, IPx8**	1	1	--	2[a b]	--	2[a b]	--
Constant heating within the equipment with an ENCLOSURE **of IPx4 or higher**	1	--	--	--	--	--	--
Hermetically sealed ENCLOSURE	1	1	1	1	1	1	1

NOTE 1 Reduction maximum to PD 1.

NOTE 2 PD 3 and PD 4 not considered as controlled environment.

NOTE 3 Reduction measures are meant as alternatives.

NOTE 4 IP classification based on IEC 60529.

[a] Conformal coating, further 1 POLLUTION DEGREE reduction.

[b] Potting or encapsulation, further 1 POLLUTION DEGREE reduction.

-- = no reduction

NOTE Examples of how to use Table E.1 and Table E.2:

1) Equipment in an external environment of PD = 2 and environmental situation = B protected by an ENCLOSURE IPx7 or IPx8 gets a reduction to PD = 1.

2) Equipment in an external environment of PD = 3 and environmental situation = B protected by an ENCLOSURE IPx7 or IPx8 gets a reduction to PD = 2, and with additional protection by conformal coating gets a reduction to PD = 1.

Annex F
(normative)

ROUTINE TESTS

F.1 General

The manufacturer shall perform the tests of F.2 to F.4 on 100 % of equipment produced which has both HAZARDOUS LIVE parts and ACCESSIBLE conductive parts. Unless it can be clearly shown that the result of the tests cannot be invalidated by subsequent manufacturing stages, tests shall be made with equipment fully assembled. Components shall not be unwired, modified or disassembled for the test, but snap-on covers and friction-fit knobs may be removed if they would interfere with the tests. The equipment shall not be energized during the tests, but the MAINS switch shall be in the on-position.

Wrapping the equipment in foil is not required, nor is humidity preconditioning necessary.

Test site altitude correction of the test voltage is not required.

The voltage test equipment shall be able to maintain the required voltage for the specified period of time. No other requirements apply.

Conformity is checked by inspection.

F.2 Protective earth

A continuity test is made between the earth pin of the appliance inlet or the MAINS plug of plug-connected equipment, or the PROTECTIVE CONDUCTOR TERMINAL of PERMANENTLY CONNECTED EQUIPMENT on the one side, and all ACCESSIBLE conductive parts which are required by 6.5.2 to be connected to the PROTECTIVE CONDUCTOR TERMINAL on the other side.

The resistance shall not exceed 0,1 Ω.

NOTE No value is specified for the test current.

F.3 MAINS CIRCUITS

F.3.1 General

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1 a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

A test voltage is applied between:

a) the MAINS TERMINALS connected together, and

b) all ACCESSIBLE conductive parts including the PROTECTIVE CONDUCTOR TERMINAL, if any, connected together.

During this test, the equipment shall be electrically isolated from any external earthing. This test is not applied to small metal parts such as name plates, screws or rivets, if they are separated from parts which are HAZARDOUS LIVE by REINFORCED INSULATION or its equivalent.

NOTE For equipment which has all ACCESSIBLE conductive parts connected to the PROTECTIVE CONDUCTOR TERMINAL, the interconnection of the ACCESSIBLE conductive parts is not necessary because the correct interconnections are tested by F.2.

The test voltage may be a.c. or d.c. or impulse, and is selected from Table F.1 for the appropriate OVERVOLTAGE CATEGORY. For the a.c. and d.c. tests, the test voltage is raised to its specified value within 5 s, and maintained for at least 2 s. Impulse tests are the 1,2/50 µs test specified in IEC 61180, conducted for a minimum of three pulses of each polarity at 1 s minimum intervals.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, nor shall the test device indicate failure.

Table F.1 – Test voltages for ROUTINE TESTS of MAINS CIRCUITS

Nominal line-to-neutral voltage of MAINS supply	OVERVOLTAGE CATEGORY II			OVERVOLTAGE CATEGORY III			OVERVOLTAGE CATEGORY IV		
a.c. r.m.s. or d.c.	a.c.	d.c.	1,2/50 µs Impulse	a.c.	d.c.	1,2/50 µs Impulse	a.c.	d.c.	1,2/50 µs Impulse
V	V r.m.s.	V	V peak	V r.m.s.	V	V peak	V r.m.s.	V	V peak
≤150	840	1 200	1 200	1 400	2 000	2 000	2 200	3 100	3 100
>150 ≤ 300	1 400	2 000	2 000	2 200	3 100	3 100	3 300	4 700	4 700
>300 ≤ 600	2 200	3 100	3 100	3 300	4 700	4 700	4 300	6 000	6 000
>600 ≤ 1 000	3 300	4 700	4 700	4 300	6 000	6 000	5 300	7 500	7 500

F.3.2 MAINS CIRCUITS with voltage limiting devices

For MAINS CIRCUITS with voltage limiting devices that meet the requirements of 14.8, the a.c. or d.c. test of F.3.1 can be carried out using a test voltage of 0,9 times the clamping voltage of the voltage limiting device but not less than twice the WORKING VOLTAGE of the MAINS CIRCUIT.

F.4 Floating circuits

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1, a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

A test voltage is applied between

a) the TERMINALS of floating input and output circuits, which can be HAZARDOUS LIVE in NORMAL USE, connected together, and

b) ACCESSIBLE conductive parts connected together.

The value of the applied voltage in each case is 1,5 times the maximum RATED voltage to earth but not less than 350 V a.c. r.m.s or 500 V d.c. If voltage-limiting (clamping) devices clamp below the applied voltage, the value of the applied voltage is 0,9 times the clamping voltage, but not less than that of the maximum RATED voltage to earth.

The test voltage is raised to its specified value within 5 s and maintained for at least 2 s, with the circuit electrically isolated from any external earthing means.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test nor shall the test device indicate failure.

F.101 Supply circuits other than MAINS and floating circuits

These are supply circuits other than those defined in Clause F.3 and Clause F.4.

A test voltage is applied between

a) the supply circuit, and
b) all input and output TERMINALS of all other circuits which have to be isolated from the supply circuit in a), connected together.

During this test, the control equipment shall be electrically isolated from any external earth.

This test is not applied to small metal parts for example name plates, screws or rivets, since they are not normally connected to any circuit.

The test voltage may be a.c. or d.c. or impulse, and is selected from IEC 61010-1:2010, Table F.1 for the appropriate OVERVOLTAGE CATEGORY. For the a.c. and d.c. tests, the test voltage is raised to its specified value within 5 s, and maintained for at least 2 s. Impulse tests are the 1,2/50 μs test specified in IEC 61180, conducted for a minimum of three pulses of each polarity at 1 s minimum intervals.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, nor shall the test device indicate failure.

No test is required for SELV/PELV CIRCUITS/units.

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1 a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

Annex G
(informative)

Leakage and rupture from fluids under pressure

The requirements and tests of this annex are accepted in the USA, Canada, and in some other countries, as proof of conformity with national regulations relating to high pressures. These requirements are not adequate for equipment intended for toxic, flammable, or otherwise hazardous materials. Refer to national authorities for requirements for such equipment.

G.1 General

Fluid-containing parts of equipment under pressure shall not cause a HAZARD through rupture or leakage in NORMAL CONDITION or SINGLE FAULT CONDITION.

Conformity is checked as specified in Clause G.2 to G.4.

G.2 Pressures above 2 MPa and a product pressure and volume greater than 200 kPa·l

G.2.1 General

Fluid-containing parts of equipment which in NORMAL USE have both of the following characteristics shall not cause a HAZARD through rupture or leakage:

a) a product of pressure and volume greater than 200 kPa·l;

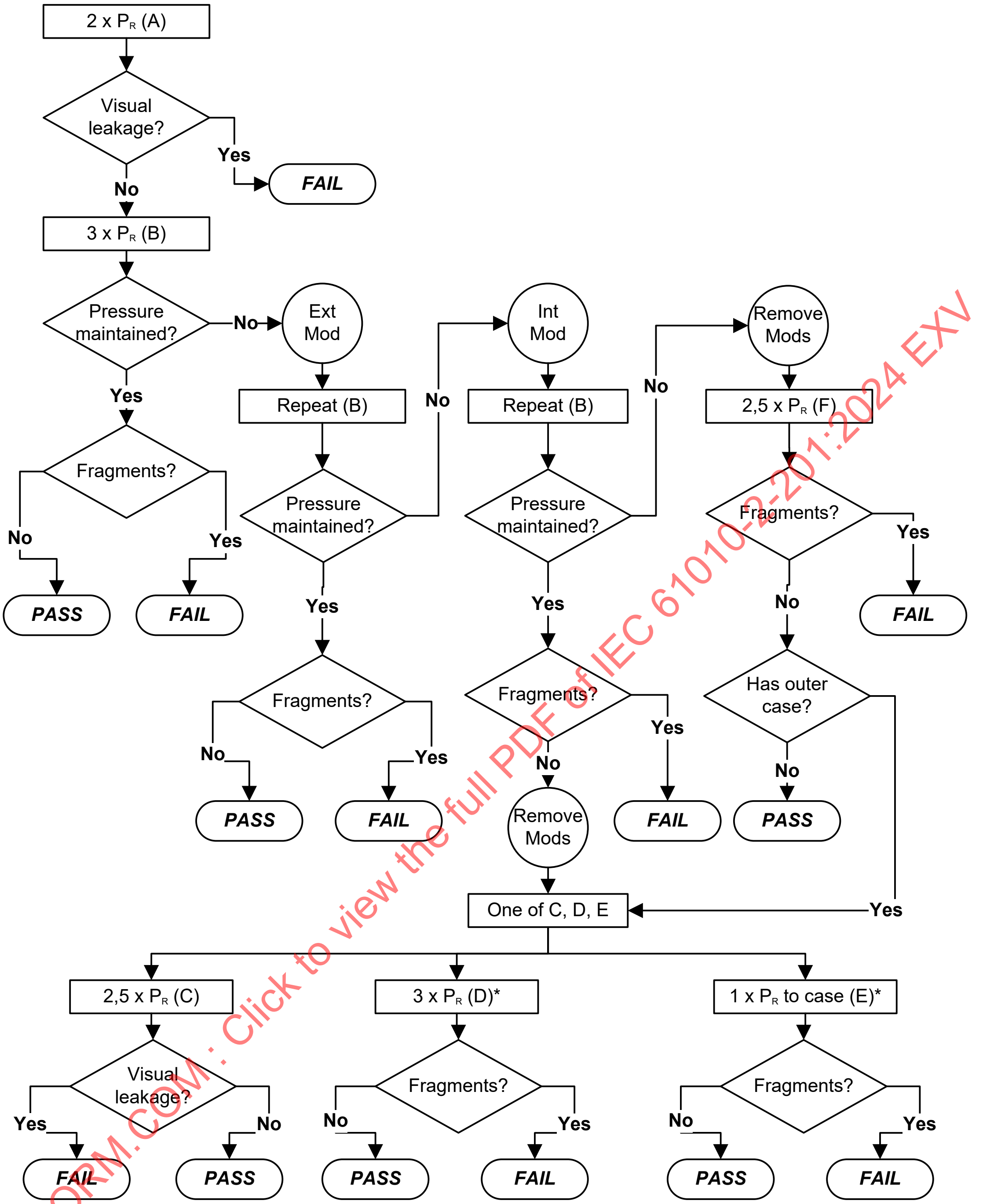
b) a pressure above 2 MPa.

NOTE Such equipment includes fluid-pressure-actuated equipment employing flexible bellows, diaphragms, Bourdon tubes, etc. and equipment such as flowmeters that are connected to process pressures RATED at or above 2 MPa.

Conformity is checked by inspection and by performing the hydrostatic tests of G.2.2 to G.2.6. Any overpressure safety device which is used to limit the maximum working pressure is inactivated during the tests.

Figure G.1 is a flow chart showing methods of conformity verification.

Throughout Clause G.2, values are based on RATED pressure P_R. This is the maximum pressure as marked on the equipment or, if no value is marked, the maximum transient overpressure (maximum pressure which may be applied without permanent change in performance). In the case of differential pressure equipment, the RATED pressure is the higher of the working pressure and the static pressure.



Subclause references for tests A to F:

A = G.2.3 a) - B = G.2.3 b) - C = G.2.5 a) - D = G.2.5 b) - E = G.2.5 c) - F = G.2.6 - P_R = RATED pressure

Figure G.1 – Conformity verification process (see G.2)

G.2.2 Conduct of hydrostatic tests for G.2.1

The part of the equipment that is normally subjected to the fluid pressure is filled with a suitable liquid, such as water, to exclude air, and is then connected to a hydraulic pump. The pressure is raised gradually to the specified test pressure.

Those portions of the equipment which normally receive indirect pressure loading, as in hydraulically coupled systems, are subjected to the test pressure at the same time, either through the original hydraulic filling fluid or, in its absence, by filling with the test liquid.

Test pressure values are based on RATED pressure P_R, see G.2.1.

Test pressure values specified in G.2.3 to G.2.6 apply to equipment with RATED pressure up to 14 MPa. For higher RATED pressures the values of Table G.1 apply.

Where it is specified in these test procedures that pressure is to be applied to "the equipment", the pressure shall be applied to that part of the equipment that is subjected to pressure in NORMAL USE.

Where it is specified in these test procedures that pressure is to be applied to "the outer casing", the pressure shall be applied to any unpressurized case, cover, enclosure, or housing that encloses all or part of the pressurized equipment, but that is not itself intended to be pressurized in NORMAL USE.

G.2.3 Initial tests

The following tests are performed.

a) A pressure of 2 × P_R is applied to the equipment for 1 min without any visible leakage.

b) A pressure of 3 × P_R is applied to the equipment for 1 min without any rupture or failure which results in fragments flying outside the equipment.

During test b), leakage may occur because of splits in Bourdon tubes, diaphragms, or bellows, or because of joint or gasket failure. These are not considered to be test failures if the pressure can be maintained for 1 min. However, if leakage is at a rate which prevents pressure being maintained for 1 min, the modifications specified in G.2.4 may be made, and the test repeated.

1) If the equipment passes the test of G.2.3 b) after modification only as specified in G.2.4 a), no further tests are performed.

2) If the equipment passes the test of G.2.3 b) after modification as specified in G.2.4 b), the modifications are removed, and one of the tests of G.2.5 is performed.

3) If the equipment again fails the test of G.2.3 b), the modifications are removed and the test of G.2.6 is performed.

G.2.4 Modifications to minimize leakage

The following modifications may be made.

a) External fittings may be modified to reduce leakage.

b) A leaking gasket or a flexible seal (not part of the measuring element) which forms a structural partition between the part of the equipment that is under pressure in NORMAL USE and the outer casing may be replaced by a stronger non-functional member to reduce leakage.

G.2.5 Additional tests if modification succeeded in minimizing leakage

If any modification as specified in G.2.4 b) was made before successfully repeating the test of G.2.3 b), the equipment is restored to its original state, and one of tests a), b) or c) below is performed on the unmodified equipment. For equipment intended for toxic, flammable or otherwise hazardous substances, test a) is performed.

a) A pressure of 2,5 × P_R is applied to the equipment for 1 min without any visible leakage.

b) A pressure of 3 × P_R is applied to the equipment for 1 min without any rupture or failure which results in fragments flying outside the outer casing.

NOTE 1 In this case, even if the pressure of 3 × P_{RATED} cannot be maintained within the equipment, leakage from the outer casing takes place at a rate which prevents a build-up of hazardous pressure.

c) *If the equipment has an outer casing capable of being pressurized, it is subjected to a pressure of P_R for 1 min without any rupture or failure which results in fragments flying outside the outer casing.*

NOTE 2 In this situation, rupture and flying fragments are prevented by the capability of the outer casing to resist pressure.

G.2.6 Additional test if modifications failed to reduce leakage

If the equipment failed the test of G.2.3 b) after the modifications of G.2.4, but the leakage serves as a pressure relief mechanism, the equipment conforms to the requirements of G.2.3 b) if, after removal of the modifications, it passes the test specified below and, if the equipment has an outer casing, also passes one of tests a), b), and c) of G.2.5.

A pressure of 2,5 x P_R is applied to the equipment for 1 min without any rupture or failure which results in fragments flying outside the equipment.

Table G.1 – Test pressures for equipment with pressures above 14 Mpa

P_R	Pressure for test of G.2.5 c)	Pressure for test of G.2.3 a)	Pressure for tests of G.2.5 a) and G.2.6	Pressure for tests of G.2.3 b) and G.2.5 b)
>14 ≤ 70 MPa	P_R	1,75 × P_R plus 3,5 MPa	2,0 × P_R plus 7 MPa	2,5 × P_R plus 7 MPa
>70 MPa	P_R	1,3 × P_R plus 35 MPa	1,5 × P_R plus 42 MPa	2,0 × P_R plus 42 MPa

G.3 Pressures between 50 kPa and 2 MPa, and pressure times volume above 200 kPa·l

Fluid-containing parts of equipment which in NORMAL USE have both of the following characteristics shall not cause a HAZARD through rupture or leakage:

a) a product of pressure and volume greater than 200 kPa·l;

b) a pressure between 50 kPa and 2 MPa.

Conformity is checked by a hydrostatic test conducted as specified in G.2.2. Any overpressure safety device which is used to limit the maximum working pressure is inactivated during the test.

A pressure of 3 × P_R is applied to the equipment for 1 min without leakage, permanent (plastic) deformation, or bursting. However, for equipment not intended for use with toxic, flammable, or otherwise hazardous substances, leakage at a gasket at a pressure above 1,2 × P_R is acceptable.

If a hydrostatic test cannot be performed on unmarked fluid-containing parts or pipes, their integrity is verified by suitable equivalent tests, such as pneumatic tests at 3 × P_R.

For refrigeration systems see applicable national standards for example ANSI/UL 471, CSA C22.2 No 120.

G.4 Pressures below 50 kPa, or pressure times volume below 200 kPa·l

Leakage from fluid-containing parts at lower pressures, or with a product of pressure and volume below 200 kPa·l, shall not cause a HAZARD.

Conformity is checked by inspection of the RATINGS of parts and, if necessary, by subjecting the parts to a fluid pressure of twice the maximum pressure in NORMAL USE. The pressure is applied for 1 min. No leakage is to occur which could cause a HAZARD.

G.5 Overpressure safety devices

An overpressure safety device shall not operate in NORMAL USE and shall conform to all the following requirements.

a) It shall be connected as close as possible to the fluid-containing parts of the system that it is intended to protect.

b) It shall be installed so as to provide easy access for inspection, maintenance and repair.

c) It shall not be capable of being adjusted without the use of a TOOL.

d) It shall have its discharge outlet located and directed so that the released material is not directed towards any person.

e) It shall have its discharge outlet located and directed so that operation of the device will not cause a HAZARD by depositing material that could cause deterioration of parts.

f) It shall have sufficient discharge capacity to ensure that the pressure will not exceed $1{,}1 \times P_R$ if there is a failure of the supply pressure control.

g) There shall be no shut-off valve between any overpressure safety device and the parts that it is intended to protect.

Also see 11.7.4.

Conformity is checked by inspection and test.

Annex H
(normative)

Qualification of conformal coatings for protection against POLLUTION

H.1 General

This annex covers requirements for conformal coatings used on printed wiring boards to reduce the POLLUTION DEGREE.

Conformal coatings shall meet the requirements of Clause H.2 and H.3.

NOTE 1 The requirements of Clause H.2 assure that the conformal coating has been suitably RATED for the purpose of coating printed wiring boards. The requirements of H.3 assure that the coating will continue to adhere to the printed wiring board after environmental and physical stresses.

Conformity is checked as specified in Clauses H.2 and H.3.

NOTE 2 Conformal coatings that meet the requirements of ANSI/UL 746E are considered to meet these requirements.

H.2 Technical properties

The technical properties of conformal coatings shall be suitable for the intended application. In particular:

a) the manufacturer of the coating material shall state that it is a coating for printed wiring boards;
b) the RATED operating temperature range shall include the temperature range of the intended application;
c) the comparative tracking index (CTI), the insulation resistance and the dielectric strength shall be suitable for the intended application;
d) if the printed wiring board coating is to be exposed to sunlight, the coating shall have adequate UV resistance;
e) the flammability RATING of the coating shall be at least the required flammability RATING of the printed wiring board to which it is applied.

Conformity is checked by inspection of the manufacturer's data.

H.3 Qualification of coatings

The coating shall meet the conformity requirements of Figure H.1 after the tests of Table H.1.

Conformity is checked as specified in Table H.1 and Figure H.1, on 6 specimens of the coated printed wiring board.

Table H.1 – Test parameters, test conditions and test procedures

Item	Test, conditioning	Test parameter, conditions	Test procedure
1	Cold conditioning	Conditioning temperature: T_{min}. T_{min} is the minimum RATED ambient temperature or the minimum RATED storage temperature, whichever is lower, of the specimen. Any humidity is acceptable. Conditioning time: 24 h	The specimens are placed in a temperature chamber and held at T_{min} for the specified conditioning time.
2	Dry heat	Conditioning temperature: T_{max}. T_{max} is the maximum RATED surface temperature, maximum RATED ambient temperature, or maximum RATED storage temperature, whichever is higher, of the specimen. Any humidity is acceptable. Conditioning time: 48 h	The specimen is placed in a temperature chamber and held at T_{max} for the specified conditioning time.
3	Rapid change of temperature	Maximum temperature: T_{max} T_{max} is the maximum RATED surface temperature, maximum RATED ambient temperature, or maximum RATED storage temperature, whichever is highest, of the specimen. Minimum temperature: T_{min}. T_{min} is the minimum RATED ambient temperature or the minimum RATED storage temperature, whichever is lower, of the specimen. Rate of change of temperature: within 30 s Cycle time (duration of one cycle): T_{max} and T_{min} are each held until steady state conditions of the specimens are achieved and then maintained for 10 min. The cycle starts when the specimen has reached the target within 2° C. Number of cycles: 50 cycles	The conditioning procedure follows test Na of IEC 60068-2-14.
4	Damp heat	Temperature: 40 °C ± 2 °C Humidity: 90 %...95 % R.H. Conditioning time: 24 h	The specimens are placed in the humidity chamber and held at the specified temperature and humidity for the specified conditioning time.
5	Adhesion of coating	Temperature: 15 °C.... 35 °C Humidity: 45 %.... 75 % R.H. Pull force: 5 N	The test procedure follows the test described in 5.8.2 of IEC 60664-3 using the specified pull force.
6	Humidity conditioning	Temperature: 40 °C ± 2 °C Humidity: 90 %...95 % R.H. Conditioning time: 48 h	The specimens are placed in the humidity chamber and held at the specified temperature and humidity for the specified conditioning time.
7	Insulation resistance of conductors	Temperature : 40 ± 2 °C Humidity: 90 %...95 % R.H. Insulation resistance: ≥100 MΩ	Insulation resistance is measured between the two outer conductors with the smallest CREEPAGE DISTANCE for at least 1 min. The test voltage shall be as close to the WORKING VOLTAGE as possible.

Figure H.1 (below) describes the test sequence and conformity.

Preparation and scratch resistance	
Preparation of the test specimens	Each specimen is to be assembled in the normal manner, using the normal soldering procedure, including any cleaning and protection steps that are normally applied.
Visual inspection	*Conformity is checked by inspection.* The specimens shall show no: ▪ separation from base material, ▪ cracks, ▪ voids, ▪ areas with adjacent unprotected conductive parts where the CREEPAGE DISTANCE between the parts is less than the required CREEPAGE DISTANCE for uncoated printed wiring boards. *NOTE Areas of the specimens where scratch resistance test is applied need not be involved in the subsequent testing and inspection.*

Conditioning of the test specimens	
Table H.1, item 1	Cold conditioning
Table H.1, item 2	Dry heat
Table H.1, item 3	Rapid change of temperature
Table H.1, item 4	Damp heat test

Mechanical and electrical tests after conditioning	
Table H.1, item 5	Adhesion of coating (tape test)
Visual inspection	*Conformity is checked by inspection.* On all specimens, the coating shall not have loosened and there shall be no material transferred to the tape that is visible to the naked eye. *NOTE In order to assess whether there has been any transfer of material, the tape can be placed on a sheet of white paper or card. If a white or light-coloured coating is being tested, a suitably contrasting coloured paper or card is used instead.*
Table H.1, item 6	Humidity conditioning
Table H.1, item 7	Insulation resistance *Conformity is checked by measuring of the insulation resistance of Table H.1, item 7. All specimens shall meet the required value.*

Visual inspection	*Conformity is checked by inspection.* All specimens shall show no ▪ blistering, ▪ swelling, ▪ separation from base material, ▪ cracks, ▪ voids, ▪ areas with adjacent unprotected conductive parts where the CREEPAGE DISTANCE between the parts is less than the required CREEPAGE DISTANCE for uncoated printed wiring boards.

IEC 1031/10

Figure H.1 – Test sequence and conformity

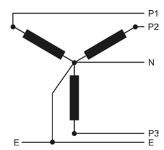
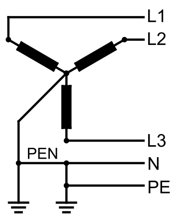
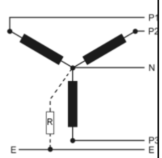
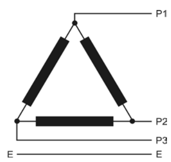
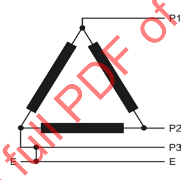
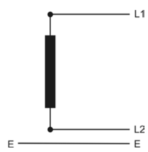
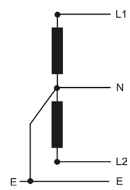
Annex I
(informative)

Line-to-neutral voltages for common MAINS supply systems

For the purposes of this standard, Table I.1 gives the line-to-neutral voltage that should be used for determining CLEARANCE, CREEPAGE DISTANCE, and solid insulation requirements of MAINS circuits.

Table I.1 is derived from Table B.1 of IEC 60664-1. It is applicable to MAINS supply systems with inherent control (see IEC 60664-1, 4.3).

Table I.1 – Line-to-neutral voltages for common MAINS supply systems

MAINS systems and nominal voltages						Line-to-neutral voltage pertinent to MAINS system type and nominal voltage
Three-phase four-wire systems [a] with earthed neutral TT system  TN-C-S System 	Three-phase four-wire systems [a] with unearthed neutral (IT systems) [b, c] 	Three-phase three-wire systems unearthed 	Three-phase three-wire systems with earthed phase 	Single-phase two-wire systems a.c. or d.c. 	Single-phase (split-phase) three-wire systems [a] a.c. or d.c. 	
V	V	V	V	V	V	V
				12,5 to 48	30/60	50
66/115		66		60		100
120/208 127/220	120/208	110, 115 120, 127	100 120	100 110, 115 120, 127	100/200 [d] 110/220 115/230 120/240	150
220/380 230/400 240/415 260/440 277/480	230/400 277/480	200 220, 230, 240 260, 277, 347 380, 400, 415 440, 480	200 240	220 230 240	220/440 240/480	300

347/600 380/660 400/690 417/720 480/830	347/600 400/690	500 577 600	347 380, 400, 415 440, 480, 600	480	480/960	600
		660 690, 720 830, 1 000		1 000		1 000

[a] Voltages shown as two voltages separated by a "/" represent the phase-to-neutral (or line-to-neutral) voltage followed by the phase-to-phase (or line-to-line) voltage. For example, "120/208" indicates that the voltage from any phase to neutral is 120 V, and the voltage from any phase to another phase is 208 V. Likewise, "220/440" indicates that the voltage from either line-to-neutral is 220 V, and the voltage from line-to-line is 440 V.

[b] *Z* is an impedance which may connect neutral to earth (usually 1 500 Ω).

[c] When insulation is monitored, neutral of these systems is considered to be earthed.

[d] Practise in Japan.

Annex J
(informative)

RISK assessment

A RISK assessment process based on ISO/IEC Guide 51 (1999) is given below. Other RISK assessment procedures are contained in ISO 14971, SEMI S10, IEC 61508, ISO 14121-1, and ANSI TR3. Other established procedures which implement similar steps can also be used.

J.1 RISK assessment procedure

TOLERABLE RISK is achieved by the iterative process of RISK assessment (RISK analysis and RISK evaluation) and RISK reduction (see Figure J.1).

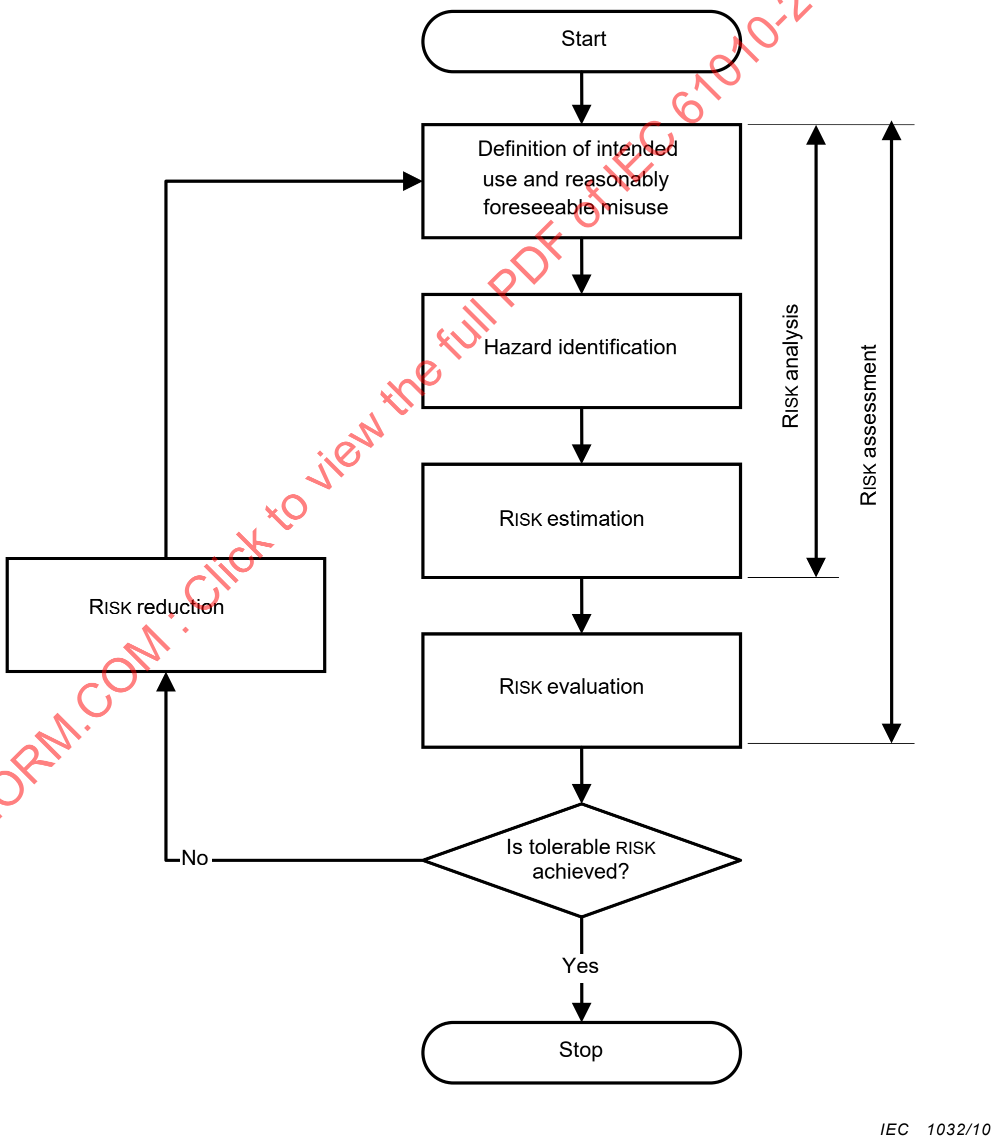


Figure J.1 – Iterative process of RISK assessment and RISK reduction

J.2 Achieving TOLERABLE RISK

The following procedure (see Figure J.1) should be used to reduce RISKS to a tolerable level:

a) identify the likely user group(s) for the product, process, or service (including those with special needs and the elderly), and any known contact group (e.g. use or contact by children);

b) identify the intended use and assess the REASONABLY FORESEEABLE MISUSE of the product, process or service;

c) identify each HAZARD (including any hazardous situation and harmful event) arising in all stages and conditions for the use of the product, process or service, including installation, maintenance, repair, and destruction or disposal;

d) estimate and evaluate the RISK (see Figure J.1) to each identified user/contact group arising from each HAZARD identified;

e) judge if the RISK is tolerable (e.g. by comparison with similar products, processes or services);

f) if the RISK is not tolerable, reduce the RISK until it becomes tolerable.

When reducing RISKS the order of priority should be as follows:

1) eliminate or reduce RISKS as far as possible (inherently safe design and construction);

2) take the necessary protection measures in relation to RISKS that cannot be eliminated (protection devices);

3) inform users of the residual RISKS due to any shortcomings of the protection measures adopted, indicate whether any particular training is required, and specify any need to provide personal protection equipment (information for safety).

This procedure is based on the assumption that the user has a role to play in the RISK reduction procedure by complying with the information provided by the manufacturer (see Figure J.2).

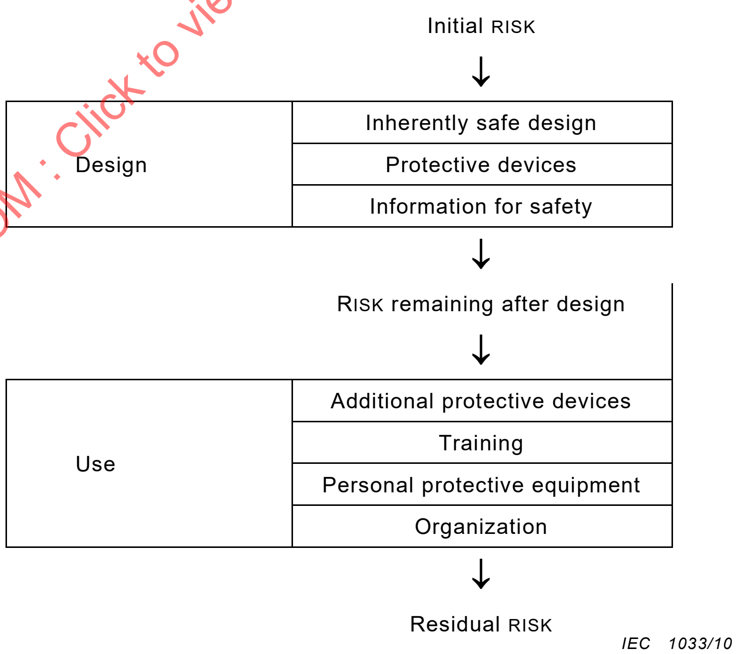


Figure J.2 – RISK reduction

The steps taken in the design procedure are shown in order of priority. The steps to be taken by the user are not in order of priority because this would depend on the application. It is emphasized that the additional protection devices, personal protection equipment and provision of information to users should not be used as substitutes for design improvements.

J.3 An application of RISK assessment procedures

For HAZARDS in the scope of this standard, examples of severity of harm are given in Table J.1. Probability of harm is given in Table J.2. The RISK category, which is selected based on severity and probability, is given in Table J.3.

Table J.1 – Severity of harm

Severity group	People	Equipment / Facility	Environment
Catastrophic	One or more fatalities	System or facility loss	Chemical release with acute or public health impact
Severe	Disabling injury/illness	Major subsystem loss or facility damage	Chemical release with temporary environmental or public health impact
Moderate	Medical treatment or restricted work activity	Minor subsystem loss or facility damage	Chemical release triggering external reporting requirements
Minor	First aid only	Non-serious equipment or facility damage	Chemical release requiring only routine cleanup without reporting

Table J.2 – Probability of harm

Likelihood	Expected rate of occurrence
Frequent	More than five times a year
Likely	More than once per year, but not more than five times a year
Possible	More than once in five years, but not more than one a year
Rare	More than once in ten years, but not more than one in five years
Unlikely	No more than once in ten years

Table J.3 – RISK category

RISK assessment / RISK category						
Severity of harm		Probability of harm				
		Frequent	Likely	Possible	Rare	Unlikely
Severity	Catastrophic	3	3	3	2	2
	Severe	3	3	2	2	1
	Moderate	3	2	1	1	1
	Minor	2	1	1	1	1

Key	Category	Description
1	Broadly acceptable	This fulfils the requirement for TOLERABLE RISK.
2	As low as reasonably practicable	This does not automatically fulfil the requirement for TOLERABLE RISK. If possible, these RISKS should be reduced further to Category 1. If not possible, then the instructions should contain a description of the RISK so that the RESPONSIBLE BODY can take appropriate steps to protect the safety of OPERATORS.
3	Intolerable	This contains RISKS that are not TOLERABLE RISKS.

Annex K
(normative)

Insulation requirements not covered by 6.7

K.1 Insulation for MAINS CIRCUITS

K.1.1 General

The concept of OVERVOLTAGE CATEGORIES is elaborated in IEC 60364 and in IEC 60664-1. The descriptions below are made up of edited extracts from these two standards.

An OVERVOLTAGE CATEGORY is, as the definition 3.5.17 states, a numeral defining a TRANSIENT OVERVOLTAGE condition. The OVERVOLTAGE CATEGORIES are created to achieve insulation coordination between different parts of the MAINS supply installation. IEC 60364-4-44 says that 'Impulse withstand (overvoltage) categories are to distinguish different degrees of availability of equipment with regard to required expectations on continuity of service and on an acceptable probability of failure'. This means that the decision of the appropriate RATING of the OVERVOLTAGE CATEGORY of a piece of equipment may be made on grounds of reliability as well as on grounds of safety. In this standard, requirements in Clauses 5 to 16 apply to equipment not forming part of the building installation, and the requirements for CLEARANCES and CREEPAGE DISTANCES are based on OVERVOLTAGE CATEGORY II, with MAINS voltages up to 300 V.

Equipment forming part of the building installation may include installation material, equipment intended to measure or control the MAINS supply within the building, and similar equipment. All such equipment is permanently connected to the MAINS, and is permanently installed in the building. However, equipment that utilizes the MAINS supply only for powering itself and associated equipment is not considered to be part of the building installation, even if it is permanently connected or permanently installed in the building.

If a manufacturer rates equipment for OVERVOLTAGE CATEGORY III OR OVERVOLTAGE CATEGORY IV, the relevant requirements of this annex apply.

OVERVOLTAGE CATEGORY I is used, within the context of IEC 60364-4-44, for equipment intended to be connected to a MAINS supply in which means have been taken to substantially and reliably reduce TRANSIENT OVERVOLTAGES to a level where they cannot cause a HAZARD. OVERVOLTAGE CATEGORY I is not relevant to this standard.

OVERVOLTAGE CATEGORY II is for equipment intended to be supplied from the building wiring. It applies both to plug-connected equipment and to PERMANENTLY CONNECTED EQUIPMENT. Subclause 6.7 covers only the requirements for OVERVOLTAGE CATEGORY II with a nominal supply voltage up to 300 V. The requirements for higher OVERVOLTAGE CATEGORIES and for OVERVOLTAGE CATEGORY II with a nominal supply voltage above 300 V are covered by this annex.

OVERVOLTAGE CATEGORY III is for equipment intended to form part of a building wiring installation. Such equipment includes socket outlets, fuse panels, and some MAINS installation control equipment. Manufacturers may also design equipment for OVERVOLTAGE CATEGORY III when a higher degree of reliability and availability is desired.

OVERVOLTAGE CATEGORY IV is for equipment installed at or near the origin of the electrical supply to a building, between the building entrance and the main distribution board. Such equipment may include electricity tariff meters and primary overcurrent protection devices. Manufacturers may also design equipment for OVERVOLTAGE CATEGORY IV when an even higher degree of reliability and availability is desired.

K.1.2 CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS

CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS shall meet the values of the following tables as applicable:

a) for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II, with nominal supply voltages above 300 V, Table K.2;

b) for MAINS CIRCUITS of OVERVOLTAGE CATEGORY III, Table K.3;

c) for MAINS CIRCUITS of OVERVOLTAGE CATEGORY IV, Table K.4.

NOTE 1 See Annex I for nominal voltages of MAINS supplies.

The values in the following tables are for BASIC INSULATION and SUPPLEMENTARY INSULATION. Values for REINFORCED INSULATION shall be twice the values for BASIC INSULATION.

If the equipment is RATED to operate at an altitude greater than 2 000 m, the CLEARANCES shall be multiplied by the applicable factor of Table K.1.

NOTE 2 Material group IIIb is not recommended for application in POLLUTION DEGREE 3 above line-to-neutral voltages of 630 V.

Conformity is checked by inspection and measurement and, in case of doubt, by the impulse voltage test of 6.8.3.3 or the a.c. test of 6.8.3.1 with a duration of at least 5 s using the applicable test voltage from Table K.16 for the required CLEARANCE.

No flashover of CLEARANCES shall occur during the test.

Table K.1 – Multiplication factors for CLEARANCES for equipment RATED for operation at altitudes up to 5 000 m

RATED operating altitude m	Multiplication factor
Up to 2 000	1,00
2 001 to 3 000	1,14
3 001 to 4 000	1,29
4 001 to 5 000	1,48

Table K.2 – CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II above 300 V

Voltage line-to-neutral a.c. r.m.s. or d.c.	Values for CLEARANCE	Values for CREEPAGE DISTANCE								
		Printed wiring board material		Other insulating material						
		POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 1	POLLUTION DEGREE 2			POLLUTION DEGREE 3		
		All material groups	Material groups I, II, IIIa	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III
V	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
>300 ≤ 600	3,0	3,0	3,0	3,0	3,0	4,3	6,0	7,5	8,3	9,4
>600 ≤ 1 000	5,5	5,5	5,5	5,5	5,5	7,2	10,0	12,5	14,0	16,0

Table K.3 – CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS of OVERVOLTAGE CATEGORY III

Voltage line-to-neutral a.c. r.m.s. or d.c.	Values for CLEARANCE	Values for CREEPAGE DISTANCE								
		Printed wiring board material		Other insulating material						
		POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 1	POLLUTION DEGREE 2			POLLUTION DEGREE 3		
		All material groups	Material groups I, II, IIIa	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III
V	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
≤150	1,5	1,5	1,5	1,5	1,5	1,5	1,6	2,0	2,2	2,5
>150 ≤ 300	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,8	4,1	4,7
>300 ≤ 600	5,5	5,5	5,5	5,5	5,5	5,5	6,0	7,5	8,3	9,4
>600 ≤ 1 000	8,0	8,0	8,0	8,0	8,0	8,0	10,0	12,5	14,0	16

Table K.4 – CLEARANCES and CREEPAGE DISTANCES for MAINS CIRCUITS of OVERVOLTAGE CATEGORY IV

Voltage line-to-neutral a.c. r.m.s. or d.c.	Values for CLEARANCE	Values for CREEPAGE DISTANCE								
		Printed wiring board material		Other insulating material						
		POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 1	POLLUTION DEGREE 2			POLLUTION DEGREE 3		
		All material groups	Material groups I, II, IIIa	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III
V	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
≤150	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
>150 ≤ 300	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5
>300 ≤ 600	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,3	9,4
>600 ≤ 1 000	14,0	14,0	14,0	14,0	14,0	14,0	14,0	14,0	14,0	16,0

Coatings that meet the requirements of Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

Conformity of coatings is checked as specified in Annex H.

K.1.3 Solid insulation for MAINS CIRCUITS

K.1.3.1 General

Solid insulation of MAINS CIRCUITS shall withstand the electrical and mechanical stresses that may occur in NORMAL USE, in all RATED environmental conditions (see 1.4), during the intended life of the equipment.

NOTE 1 The manufacturer should take the expected life of the equipment into account when selecting insulating materials.

Conformity is checked by both of the following tests:

a) *the a.c. test of 6.8.3.1 with a duration of at least 5 s or the peak impulse test of 6.8.3.3 using the applicable voltages from Tables K.5, K.6 or K.7;*

b) *the a.c. test of 6.8.3.1 with a duration of at least 1 min, or for* MAINS CIRCUITS *stressed only by d.c. the 1 min d.c. test of 6.8.3.2 using the applicable voltages from Table K.8.*

NOTE 2 These two different voltage tests are required for these circuits for the following reasons. Test a) checks the effects of TRANSIENT OVERVOLTAGES, while test b) checks the effects of long-term stress of solid insulation.

NOTE 3 If the test from Tables K.5 to K.7 is performed for at least 1 min, there is no need to repeat the test of b) above.

Table K.5 – Test voltages for solid insulation in MAINS CIRCUITS of OVERVOLTAGE CATEGORY II above 300 V

Voltage line-to-neutral a.c. r.m.s. or d.c. V	Test voltage			
	5 s a.c. test V a.c. r.m.s.		Impulse test V peak	
	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION
>300 ≤ 600	2 210	3 510	4 000	6 400
>600 ≤ 1 000	3 310	5 400	6 000	9 600

Table K.6 – Test voltages for solid insulation in MAINS CIRCUITS of OVERVOLTAGE CATEGORY III

Voltage line-to-neutral a.c. r.m.s. or d.c. V	Test voltage			
	5 s a.c. test V r.m.s.		Impulse test V peak	
	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION
≤150	1 390	2 210	2 500	4 000
>150 ≤ 300	2 210	3 510	4 000	6 400
>300 ≤ 600	3 310	5 400	6 000	9 600
>600 ≤ 1 000	4 260	7 400	8 000	12 800

Table K.7 – Test voltages for solid insulation in MAINS CIRCUITS of OVERVOLTAGE CATEGORY IV

Voltage line-to-neutral a.c. r.m.s. or d.c. V	Test voltage			
	5 s a.c. test V r.m.s.		Impulse test V peak	
	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION
≤150	2 210	3 510	4 000	6 400
>150 ≤ 300	3 310	5 400	6 000	9 600
>300 ≤ 600	4 260	7 400	8 000	12 800
>600 ≤ 1 000	6 600	11 940	12 000	19 200

Table K.8 – Test voltages for testing long-term stress of solid insulation in MAINS CIRCUITS

Voltage line-to-neutral a.c. r.m.s. or d.c. V	Test voltage			
	1 min a.c. test V r.m.s.		1 min d.c. test voltage V d.c.	
	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION	BASIC INSULATION and SUPPLEMENTARY INSULATION	REINFORCED INSULATION
≤150	1 350	2 700	1 900	3 800
> 150 ≤ 300	1 500	3 000	2 100	4 200
> 300 ≤ 600	1 800	3 600	2 550	5 100
> 600 ≤ 1 000	2 200	4 400	3 100	6 200

Solid insulation shall also meet the following requirements, as applicable:

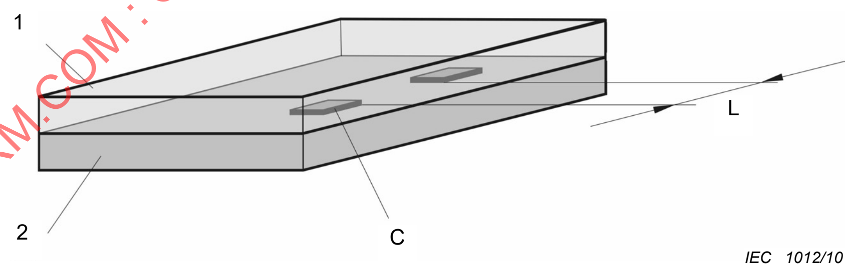
1) for solid insulation used as an ENCLOSURE or BARRIER, the requirements of Clause 8;
2) for moulded and potted parts, the requirements of K.1.3.2;
3) for inner layers of printed wiring boards, the requirements of K.1.3.3;
4) for thin-film insulation, the requirements of K.1.3.4;

Conformity is checked as specified in K.1.3.2 to K.1.3.4, and in Clause 8, as applicable.

K.1.3.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers moulded together (see Figure K.1, item L) shall be separated by at least the applicable minimum distance of Table K.9 after the moulding is completed.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key

1 Layer 1

2 Layer 2

C Conductor

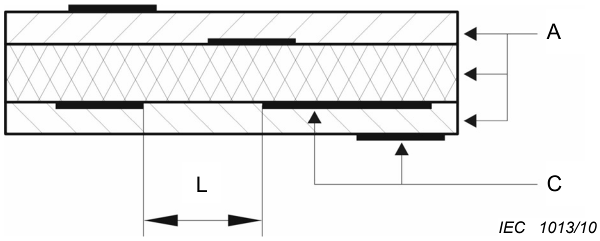
L Distance between conductors

Figure K.1 – Distance between conductors on an interface between two layers

K.1.3.3 Inner insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure K.2, item L) shall be separated by at least the applicable minimum distance of Table K.9.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key:

L Distance between adjacent conductors

A Layers

C Conductors

Figure K.2 – Distance between adjacent conductors along an interface of an inner layer

Table K.9 – Minimum values for distance or thickness of solid insulation

Line-to-neutral voltage V r.m.s. or d.c.	**Minimum thickness** **a** mm	**Minimum distance L (see Figure K.2)** **a, b** mm
≤ 300	0,4	0,4
> 300 ≤ 600	0,6	0,6
> 600 ≤ 1 000	1,0	1,0

[a] These values are independent of the OVERVOLTAGE CATEGORY.

[b] These values apply for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION.

REINFORCED INSULATION of inner insulating layers of printed wiring boards shall also have adequate electric strength through the respective layers. One of the following methods shall be used:

a) the thickness through the insulation is at least the value of Table K.9.

   Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltage of the applicable Table K.5, Table K.6 or Table K.7 for BASIC INSULATION.

   Conformity is checked by inspection of the manufacturer's specifications.

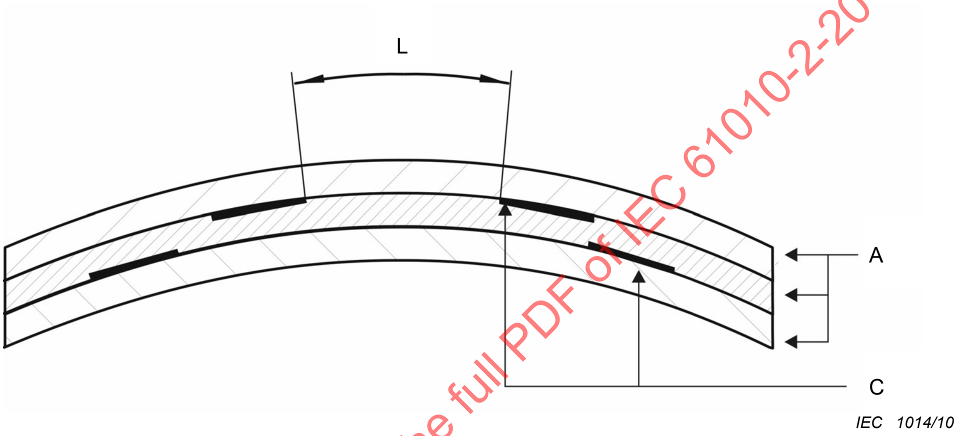
c) the insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength of at least the value of the applicable Table K.5, Table K.6 or Table K.7 for REINFORCED INSULATION.

Conformity is checked by inspection of the manufacturer's specifications.

K.1.3.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure K.3, item L) shall be separated by at least the applicable CLEARANCE and CREEPAGE DISTANCE of K.1.2.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.



Key:

L Distance between adjacent conductors

A Layers of thin-film material such as tape and polyester film

C Conductors

NOTE There may be air present between the layers

Figure K.3 – Distance between adjacent conductors located between the same two layers

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used.

a) The thickness through the insulation is at least the value of Table K.9.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) The insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the value of the test voltages from Table K.5, Table K.6 or Table K.7 as applicable for BASIC INSULATION.

Conformity is checked by inspection of the manufacturer's specifications.

c) The insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

Conformity is checked by the a.c. test of 6.8.3.1 with a duration of at least 1 min or for MAINS CIRCUITS *stressed only by d.c. the 1 min d.c. test of 6.8.3.2 applied to two of the three layers using the applicable voltage for* REINFORCED INSULATION *of Table K.5, Table K.6 or Table K.7.*

NOTE For the purposes of this test a special sample may be assembled with only two layers of the material.

K.2 Insulation in secondary circuits

K.2.1 General

In this standard, secondary circuits are circuits where separation from MAINS CIRCUITS is achieved by a transformer in which the primary windings are separated from the secondary windings by REINFORCED INSULATION, DOUBLE INSULATION, or a screen connected to the PROTECTIVE CONDUCTOR TERMINAL.

NOTE These circuits are assumed to be subjected to lower TRANSIENT OVERVOLTAGE levels than the MAINS CIRCUIT.

K.2.2 CLEARANCES

CLEARANCES for secondary circuits shall:

a) for BASIC INSULATION or SUPPLEMENTARY INSULATION, meet the applicable values of Tables K.10, K.11 and K.12, or for REINFORCED INSULATION meet twice that value; or

b) pass the voltage test of 6.8 using the applicable value of Table K.10, Table K.11 or Table K.12.

For the application of Tables K.10 to K.12, the following applies:

1) values for test voltages for REINFORCED INSULATION are 1,6 times the values for BASIC INSULATION;
2) if the equipment is RATED to operate at an altitude greater than 2 000 m, the values for CLEARANCES are multiplied by the applicable factor of Table K.1;
3) minimum CLEARANCE is 0,2 mm for POLLUTION DEGREE 2 and 0,8 mm for POLLUTION DEGREE 3.

Conformity is checked by inspection and measurement and for b) by the a.c. test of 6.8.3.1 with a duration of at least 5 s, or by the 1 min d.c. test of 6.8.3.2, using the applicable test voltage from Tables K.10 to K.12. The value of the d.c. test voltage is $\sqrt{2}$ *times the a.c. r.m.s. test voltage.*

Table K.10 – CLEARANCES and test voltages for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY II above 300 V

Secondary WORKING VOLTAGE		MAINS VOLTAGE >300 ≤ 600 V r.m.s.		MAINS VOLTAGE >600 ≤ 1 000 V r.m.s.	
a.c. r.m.s.	d.c. or a.c. peak	CLEARANCE	Test voltage	CLEARANCE	Test voltage
V	V	mm	V r.m.s.	mm	V r.m.s.
16	22,6	1,5	1 390	2,9	1 590
33	46,7	1,5	1 390	3,0	2 210
50	70	1,5	1 390	3,0	2 210
100	140	1,6	1 450	3,1	2 260
150	210	1,6	1 450	3,2	2 300
300	420	1,8	1 540	3,4	2 400
600	840	2,4	1 620	3,9	2 630
1 000	1 400	3,5	2 450	5,0	3 110
1 250	1 750	4,2	2 770	5,8	3 430
1 600	2 240	5,2	3 190	6,9	3 850
2 000	2 800	6,5	3 700	8,2	4 330
2 500	3 500	8,1	4 300	9,8	4 920
3 200	4 480	10	4 950	12	5 780
4 000	5 600	12	5 780	15	7 000
5 000	7 000	16	7 400	18	8 200
6 300	8 820	20	8 980	22	9 700
8 000	11 200	26	11 200	28	11 900
10 000	14 000	33	13 800	35	14 500
12 500	17 500	42	16 900	44	17 600
16 000	22 400	55	21 200	57	21 900
20 000	28 000	71	26 300	73	27 000
25 000	35 000	91	32 600	93	33 200
32 000	44 800	120	41 600	122	42 200
40 000	56 000	154	52 200	157	53 100
50 000	70 000	199	66 100	202	67 000
63 000	88 200	261	85 300	262	85 600
Linear interpolation is allowed.					

Table K.11 – CLEARANCES and test voltages for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY III

Secondary WORKING VOLTAGE		MAINS voltage ≤150 V a.c. r.m.s.		MAINS voltage >150 ≤ 300 V a.c. r.m.s.		MAINS voltage >300 ≤ 600 V a.c. r.m.s.		MAINS voltage >600 ≤ 1 000 V a.c. r.m.s.	
a.c. r.m.s. V	d.c. or a.c. peak V	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.
16	22,6	0,48	1 100	1,5	1 800	2,9	2 820	5,4	4 240
33	46,7	0,50	1 100	1,5	1 800	3,0	2 900	5,4	4 240
50	70	0,53	1 120	1,5	1 800	3,0	2 900	5,5	4 300
100	140	0,61	1 170	1,6	1 880	3,1	2 960	5,6	4 360
150	210	0,69	1 200	1,6	1 880	3,2	3 020	5,7	4 420
300	420	0,94	1 360	1,8	2 040	3,4	3 140	6,0	4 600
600	840	1,6	1 880	2,4	2 440	3,9	3 440	6,6	4 860
1 000	1 400	2,5	2 500	3,5	3 200	5,0	4 000	7,4	5 240
1 250	1 750	3,2	3 020	4,2	3 620	5,8	4 480	8,1	5 560
1 600	2 240	4,1	3 560	5,2	4 120	6,9	5 040	9,3	6 120
2 000	2 800	5,3	4 180	6,5	4 800	8,2	5 620	11	7 000
2 500	3 500	6,9	5 040	8,1	5 560	9,8	6 320	12	7 500
3 200	4 480	9,2	6 080	10	6 400	12	7 500	15	9 100
4 000	5 600	12	7 500	12	7 500	15	9 100	17	10 100
5 000	7 000	15	9 100	16	9 600	18	10 600	20	11 600
6 300	8 820	19	11 200	20	11 600	22	12 600	25	14 100
8 000	11 200	25	14 100	26	14 600	28	15 500	31	16 900
10 000	14 000	32	17 400	33	17 800	35	18 700	38	20 000
12 500	17 500	41	21 500	42	21 900	44	22 800	47	24 200
16 000	22 400	54	27 200	55	27 600	57	28 400	60	29 700
20 000	28 000	69	33 500	71	34 300	73	35 200	76	36 400
25 000	35 000	89	41 600	91	42 400	93	43 200	96	44 400
32 000	44 800	118	53 000	120	53 700	122	54 500	125	55 600
40 000	56 000	153	66 100	154	66 500	157	67 600	160	68 700
50 000	70 000	198	82 400	199	82 700	202	83 800	205	84 900
63 000	88 200	260	104 000	261	104 400	262	104 700	265	105 700
Linear interpolation is allowed.									

Table K.12 – CLEARANCES and test voltages for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY IV

Secondary WORKING VOLTAGE		MAINS voltage ≤150 V a.c. r.m.s.		MAINS voltage >150 ≤ 300 V a.c. r.m.s.		MAINS voltage >300 ≤ 600 V a.c. r.m.s.		MAINS voltage >600 ≤ 1 000 V a.c. r.m.s.	
a.c. r.m.s. V	d.c. or a.c. peak V	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.	CLEARANCE mm	Test voltage V a.c. r.m.s.
16	22,6	1,5	1 800	2,9	2 820	5,4	4 240	8,3	5 680
33	46,7	1,5	1 800	3,0	2 900	5,4	4 240	8,3	5 680
50	70	1,5	1 800	3,0	2 900	5,5	4 300	8,4	5 740
100	140	1,6	1 880	3,1	2 960	5,6	4 360	8,5	5 800
150	210	1,6	1 880	3,2	3 020	5,7	4 420	8,6	5 860
300	420	1,8	2 040	3,4	3 140	6,0	4 600	8,9	5 960
600	840	2,4	2 440	3,9	3 440	6,6	4 860	9,6	6 240
1 000	1 400	3,5	3 200	5,0	4 000	7,4	5 240	10	6 400
1 250	1 750	4,2	3 620	5,8	4 480	8,1	5 560	11	7 000
1 600	2 240	5,2	4 120	6,9	5 040	9,3	6 120	12	7 500
2 000	2 800	6,5	4 800	8,2	5 620	11	7 000	13	8 100
2 500	3 500	8,1	5 560	9,8	6 320	12	7 500	15	9 100
3 200	4 480	10	6 400	12	7 500	15	9 100	17	10 100
4 000	5 600	12	7 500	15	9 100	17	10 100	19	11 200
5 000	7 000	16	9 600	18	10 600	20	11 600	23	13 100
6 300	8 820	20	11 600	22	12 600	25	14 100	27	15 100
8 000	11 200	26	14 600	28	15 500	31	16 900	33	17 800
10 000	14 000	33	17 800	35	18 700	38	20 000	40	21 000
12 500	17 500	42	21 900	44	22 800	47	24 200	50	25 500
16 000	22 400	55	27 600	57	28 400	60	29 700	63	31 000
20 000	28 000	71	34 300	73	35 200	76	36 400	79	37 600
25 000	35 000	91	42 400	93	43 200	96	44 400	99	45 400
32 000	44 800	120	53 700	122	54 500	125	55 600	129	57 100
40 000	56 000	154	66 500	157	67 600	160	68 700	164	70 100
50 000	70 000	199	82 700	202	83 800	205	84 900	209	86 300
63 000	88 200	261	104 400	262	104 700	265	105 700	268	106 800
Linear interpolation is allowed.									

K.2.3 CREEPAGE DISTANCES

CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION for secondary circuits shall meet the applicable values of Table K.13, based on the WORKING VOLTAGE which stresses the insulation. Values for REINFORCED INSULATION are twice the values for BASIC INSULATION.

Conformity is checked by inspection and measurement.

Coatings that meet the requirements of Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

Conformity is checked by inspection and as specified in Annex H.

Table K.13 – CREEPAGE DISTANCES for secondary circuits

Secondary WORKING VOLTAGE a.c. r.m.s. or d.c.	Printed wiring board material		Other insulating material						
	POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 1	POLLUTION DEGREE 2			POLLUTION DEGREE 3		
	All material groups	Material group I, II or IIIa	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III [b]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,40	0,40	0,40	1,00	1,00	1,00
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,10	0,45	0,45	0,45	1,10	1,10	1,10
20	0,025	0,04	0,11	0,48	0,48	0,48	1,20	1,20	1,20
25	0,025	0,04	0,125	0,50	0,50	0,50	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,80	1,10	1,4	1,6	1,8
50	0,025	0,04	0,18	0,60	0,85	1,20	1,5	1,7	1,9
63	0,040	0,063	0,20	0,63	0,90	1,25	1,6	1,8	2,0
80	0,063	0,10	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,10	0,16	0,25	0,71	1,00	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,40	0,32	0,80	1,1	1,6	2,0	2,2	2,5
200	0,40	0,63	0,42	1,00	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,60	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9,0	10,0
800	2,4	4,0	2,4	4,0	5,6	8,0	10,0	11	12,5
1 000	3,2 [a]	5,0 [a]	3,2	5,0	7,1	10,0	12,5	14	16
1 250			4,2	6,3	9,0	12,5	16	18	20
1 600			5,6	8,0	11	16	20	22	25
2 000			7,5	10,0	14	20	25	28	32
2 500			10,0	12,5	18	25	32	36	40
3 200			12,5	16	22	32	40	45	50
4 000			16	20	28	40	50	56	63
5 000			20	25	36	50	63	71	80
6 300			25	32	45	63	80	90	100
8 000			32	40	56	80	100	110	125
10 000			40	50	71	100	125	140	160
12 500			50	63	90	125			
16 000			63	80	110	160			
20 000			80	100	140	200			
25 000			100	125	180	250			
32 000			125	160	220	320			
40 000			160	200	280	400			
50 000			200	250	360	500			
63 000			250	320	450	600			

[a] For voltages above 1 000 V, CREEPAGE DISTANCES on printed wiring board material are the same as for other insulators of the same material group.

[b] Material group IIIb is not recommended for application in pollution degree 3 above 630 V.

Linear interpolation is allowed.

K.2.4 Solid insulation

K.2.4.1 General

Solid insulation in secondary circuits shall withstand the electrical and mechanical stresses that may occur in NORMAL USE, in all RATED environmental conditions (see 1.4), during the intended life of the equipment.

NOTE The manufacturer should take the expected life of the equipment into account when selecting insulating materials.

Conformity is checked by both of the following tests:

a) by the voltage test of 6.8.3.1 for 5 s using the applicable test voltage of Table K.10, Table K.11 or Table K.12 for BASIC INSULATION and SUPPLEMENTARY INSULATION. For REINFORCED INSULATION, the values are multiplied by 1,6;

b) additionally, if the WORKING VOLTAGE exceeds 300 V, by the voltage test of 6.8.3.1 for 1 min, with a test voltage of 1,5 times the WORKING VOLTAGE for BASIC INSULATION and SUPPLEMENTARY INSULATION and twice the WORKING VOLTAGE for REINFORCED INSULATION.

Solid insulation shall also meet the following requirements, as applicable:

1) for solid insulation used as an ENCLOSURE or BARRIER, the requirements of Clause 8;
2) for moulded and potted parts, the requirements of K.2.4.2;
3) for inner insulating layers of printed wiring boards, the requirements of K.2.4.3;
4) for thin-film insulation, the requirements of K.2.4.4.

Conformity is checked as specified in K.2.4.2 to K.2.4.4 and Clause 8, as applicable.

K.2.4.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers shall be separated by the applicable minimum distance of Table K.14 (see Figure K.1, item L).

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

Table K.14 – Minimum values for distance or thickness (see K.2.4.2 to K.2.4.4)

Peak value of the a.c. or d.c WORKING VOLTAGE or recurring peak voltage kV	Minimum value mm	Peak value of the a.c. or d.c WORKING VOLTAGE or recurring peak voltage kV	Minimum value mm
>0,046 7 ≤ 0,33	0,05	>8,0 ≤ 10	3,5
>0,33 ≤ 0,8	0,1	>10 ≤ 12	4,5
>0,8 ≤ 1,0	0,15	>12 ≤ 15	5,5
>1,0 ≤ 1,2	0,2	>15 ≤ 20	8
>1,2 ≤ 1,5	0,3	>20 ≤ 25	10
>1,5 ≤ 2,0	0,45	>25 ≤ 30	12,5
>2,0 ≤ 2,5	0,6	>30 ≤ 40	17
>2,5 ≤ 3,0	0,8	>40 ≤ 50	22
>3,0 ≤ 4,0	1,2	>50 ≤ 60	27
>4,0 ≤ 5,0	1,5	>60 ≤ 80	35
>5,0 ≤ 6,0	2	>80 ≤ 100	45
>6,0 ≤ 8,0	3		

K.2.4.3 Inner insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION conductors located between the same two layers shall be separated by the applicable minimum distance of Table K.14 (see Figure K.2, item L).

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

REINFORCED INSULATION of inner insulating layers of printed wiring boards shall also have adequate electric strength through the respective layers. One of the following methods shall be used:

a) the thickness of the insulation is at least the applicable minimum distance of Table K.14.

   Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength at least the value of the test voltage of the applicable Table K.10 to K.12 for BASIC INSULATION.

   Conformity is checked by inspection of the manufacturer's specifications.

c) the insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength at least the value of the test voltage of the applicable Table K.10, Table K.11 or Table K.12 multiplied by 1,6 for REINFORCED INSULATION.

   Conformity is checked by inspection of the manufacturer's specifications.

K.2.4.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION conductors located between the same two layers (see Figure K.3, item L) shall be separated by at least the applicable CLEARANCE and CREEPAGE DISTANCE of K.2.2 and K.2.3.

Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used:

a) the thickness through the insulation is at least the applicable value of Table K.14;

   Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.

b) the insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength at least the value of the test voltage of the applicable Table K.10, Table K.11 or Table K.12 for BASIC INSULATION;

   Conformity is checked by inspection of the manufacturer's specifications.

c) the insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

   Conformity is checked by the a.c. test of 6.8.3.1 with a duration of at least 1 min, or for MAINS CIRCUITS stressed only by d.c., the 1 min d.c. test of 6.8.3.2, using the applicable voltages from Table K.10, Table K.11 or Table K.12 multiplied by 1,6, applied to two of the three layers.

   NOTE For the purposes of the test for option c), a special sample may be assembled with only two layers of the material.

K.3 Insulation in circuits not addressed in 6.7, Clause K.1 or Clause K.2

K.3.1 General

These circuits have one or more of the following characteristics:

a) the maximum possible TRANSIENT OVERVOLTAGE is limited by the supply source or within the equipment (see K.4.) to a known level below the level assumed for the MAINS CIRCUIT;

b) the maximum possible TRANSIENT OVERVOLTAGE is above the level assumed for the MAINS CIRCUIT;

c) the WORKING VOLTAGE is the sum of voltages from more than one circuit, or is a mixed voltage;

d) the WORKING VOLTAGE includes a recurring peak voltage that may include a periodic non-sinusoidal waveform or a non-periodic waveform that occurs with some regularity;

e) the WORKING VOLTAGE has a frequency above 30 kHz.

In cases a) to c), CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION are determined according to K.3.2.

In cases d) and e) CLEARANCES are determined according to K.3.3.

In all cases K.3.4 addresses CREEPAGE DISTANCE and K.3.5 solid insulation

NOTE Requirements for measuring circuits are given in IEC 61010-2-030.

K.3.2 CLEARANCE calculation

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION are determined from the following formula:

$$\text{CLEARANCE} = D_1 + F \times (D_2 - D_1)$$

where

F is a factor, determined from one of the equations:

$F = (1{,}25 \times U_w/U_m) - 0{,}25$ if $U_w/U_m > 0{,}2$

$F = 0$ if $U_w/U_m \leq 0{,}2$

where

$U_m = U_w + U_t$;

U_w = the maximum peak value of the WORKING VOLTAGE;

U_t = the maximum additional TRANSIENT OVERVOLTAGE

D_1 and D_2 are values taken from Table K.15 for U_m

where

D_1 represents the CLEARANCE that would be applicable to a TRANSIENT OVERVOLTAGE with the shape of a 1,2 × 50 µs impulse.

D_2 represents the CLEARANCE that would be applicable to the peak WORKING VOLTAGE without any TRANSIENT OVERVOLTAGE;

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

If the equipment is RATED to operate at an altitude greater than 2 000 m, the CLEARANCES shall be multiplied by the applicable factor of Table K.1.

Minimum CLEARANCE, for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, is 0,2 mm for POLLUTION DEGREE 2 and 0,8 mm for POLLUTION DEGREE 3.

NOTE 1 The insulation between the primary and secondary winding of a transformer connected to MAINS is stressed by the common mode voltage component transferred during a transient event from the primary side and the WORKING VOLTAGE across the insulation. This common mode voltage expressed as additional TRANSIENT OVERVOLTAGE together with the maximum peak value of WORKING VOLTAGE U_w form the maximum impulse voltage U_m.

For example for a MAINS CIRCUIT with a line-to-neutral voltage of 230 V r.m.s. and an impulse withstand voltage of 2 500 V_{PEAK} the common mode voltage (additional TRANSIENT OVERVOLTAGE) is calculated as follows:

U_w = 1,414 × 230 V r.m.s = 325 V_{PEAK}

U_t = 2 500 V_{PEAK} – 325 V_{PEAK} = 2 175 V_{PEAK}

Conformity is checked by inspection and measurement or by the a.c. test of 6.8.3.1 with a duration of at least 5 s or the impulse voltage test of 6.8.3.3, using the applicable voltage from Table K.16 for the required CLEARANCE.

Table K.15 – CLEARANCE values for the calculation of K.3.2

Maximum voltage	CLEARANCE		Maximum voltage	CLEARANCE	
U_m	D_1	D_2	U_m	D_1	D_2
V	mm	mm	V	mm	mm
14,1 to 266	0,010	0,010	4 000	2,93	6,05
283	0,010	0,013	4 530	3,53	7,29
330	0,010	0,020	5 660	4,92	10,1
354	0,013	0,025	6 000	5,37	10,8
453	0,027	0,052	7 070	6,86	13,1
500	0,036	0,071	8 000	8,25	15,2
566	0,052	0,10	8 910	9,69	17,2
707	0,081	0,20	11 300	12,9	22,8
800	0,099	0,29	14 100	16,7	29,5
891	0,12	0,41	17 700	21,8	38,5
1 130	0,19	0,83	22 600	29,0	51,2
1 410	0,38	1,27	28 300	37,8	66,7
1 500	0,45	1,40	35 400	49,1	86,7
1 770	0,75	1,79	45 300	65,5	116
2 260	1,25	2,58	56 600	85,0	150
2 500	1,45	3,00	70 700	110	195
2 830	1,74	3,61	89 100	145	255
3 540	2,44	5,04	100 000	165	290
Linear interpolation is allowed.					

Table K.16 – Test voltages based on CLEARANCES

Required CLEARANCE mm	Test voltage Impulse 1,2/50 µs V peak	 a.c. r.m.s. 50/60 Hz V r.m.s.
0,010	330	230
0,025	440	310
0,040	520	370
0,063	600	420
0,1	810	500
0,2	1 150	620
0,3	1 310	710
0,5	1 550	840
1,0	1 950	1 060
1,5	2 560	1 390
2,0	3 090	1 680
2,5	3 600	1 960
3,0	4 070	2 210
4,0	4 930	2 680
4,5	5 330	2 900
5,0	5 720	3 110
6,0	6 460	3 510
8,0	7 840	4 260
10,0	9 100	4 950
12,0	10 600	5 780
15,0	12 900	7 000
20	16 400	8 980
25	19 900	10 800
30	23 300	12 700
40	29 800	16 200
50	36 000	19 600
60	42 000	22 800
80	53 700	29 200
100	65 000	35 400
Liner interpolation is allowed.		

NOTE 2 Two examples of calculations follow:

EXAMPLE 1:

CLEARANCE for REINFORCED INSULATION for a WORKING VOLTAGE with peak value of 3 500 V and an additional transient voltage of 4 500 V (this can be expected within an electronic switching-circuit):

Maximum voltage U_m $U_m = U_w + U_t$ = (3 500 + 4 500) V = 8 000 V

U_w / U_m = 3 500 / 8 000 = 0,44 > 0,2

thus $F = (1{,}25 \times U_w / U_m) - 0{,}25$ = (1,25 x 3 500 / 8 000) – 0,25 = 0,297

Values derived from Table K.15 at 8 000 V:

D_1 = 8,25 mm, D_2 = 15,2 mm

CLEARANCE = $D_1 + F \times (D_2 - D_1)$ = 8,25 + 0,297 × (15,2 – 8,25) = 8,25 + 2,06 = 10,3 mm

For REINFORCED INSULATION the value is doubled. CLEARANCE = 20,6 mm.

EXAMPLE 2:

CLEARANCE for BASIC INSULATION for a circuit driven from a MAINS transformer connected to an outlet of the distribution system with a MAINS voltage of 230 V and OVERVOLTAGE CATEGORY II. The circuit includes transient overvoltage limiting devices (see 14.8 and K.3.4) which limit the maximum voltage (including transients) in the circuit to 1 000 V.

The peak value (U_w) of the voltage in the circuit is 150 V.

The maximum value of the voltage U_m is therefore 1 000 V.

U_m = 1 000 V

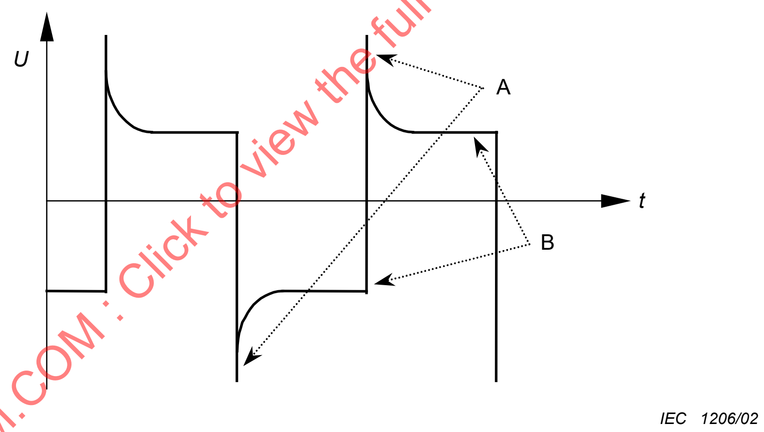
U_w / U_m = 150 / 1 000 = 0,15 < 0,2, thus F = 0

CLEARANCE D_1 = 0,15 mm interpolated from Table K.15

The CLEARANCE is then corrected for altitude and checked against POLLUTION DEGREE minimum CLEARANCES.

K.3.3 CLEARANCES in circuits having recurring peak voltages, or having WORKING VOLTAGES with frequencies above 30 kHz

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for circuits having recurring peak voltages but not subjected to frequencies above 30 kHz shall meet the values of the second column of Table K.17, using the recurring peak voltage as the index. (See Figure K.4 for an example of a recurring peak voltage.)



Key

A Peak value of recurring voltage

B Working voltage value

Figure K.4 – Example of recurring peak voltage

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for circuits that are subjected to frequencies above 30 kHz shall meet the values of the third column of Table K.17, using the peak value of the WORKING VOLTAGE as the index.

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for circuits that may be subjected to both recurring peak voltages and to frequencies above 30 kHz shall meet the higher of these requirements.

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

If the equipment is RATED to operate at an altitude greater than 2 000 m, the CLEARANCES are multiplied by the applicable factor of Table K.1.

The minimum CLEARANCE, for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, is 0,2 mm for POLLUTION DEGREE 2 and 0,8 mm for POLLUTION DEGREE 3.

Conformity is checked by inspection and measurement.

Table K.17 – CLEARANCES for BASIC INSULATION in circuits having recurring peak voltages or WORKING VOLTAGES with frequencies above 30 kHz

Voltage peak value	CLEARANCES	
	Frequencies up to 30 kHz	Frequencies above 30 kHz
V	mm	mm
0 to 330	0,01	0,02
400	0,02	0,04
500	0,04	0,07
600	0,06	0,11
800	0,13	0,26
1 000	0,26	0,48
1 200	0,42	0,76
1 500	0,76	1,1
2 000	1,27	1,8
2 500	1,8	2,6
3 000	2,4	3,5
4 000	3,8	5,7
5 000	5,7	8
6 000	7,9	10
8 000	11	15
10 000	15,2	20
12 000	19	25
15 000	25	32
20 000	34	44
25 000	44	58
30 000	55	72
40 000	77	100
50 000	100	
Linear interpolation is allowed.		

K.3.4 CREEPAGE DISTANCES

The requirements of K.2.3 apply.

Conformity is checked as specified in K.2.3.

K.3.5 Solid insulation

The requirements of K.2.4 apply except that in K.2.4.1 a), K.2.4.3 b) and c), and K.2.4.4 b) and c) the values of Table K.16 are used in place of the applicable values of Table K.10, Table K.11, or Table K.12.

To determine the required test voltage from Table K.16, the following procedure shall be applied:

a) Calculation of the theoretically required CLEARANCE according to K.3.2 considering the requirements of K.3.3. Minimum CLEARANCES for POLLUTION DEGREES 2 and 3 do not apply.
b) Application of the resulting theoretically required CLEARANCE value of Table K.16 to determine the required test voltage.

Conformity is checked as specified in K.2.4, using the test voltage determined above in place of the test voltage from Table K.10, Table K.11, or Table K.12.

K.4 Reduction of TRANSIENT OVERVOLTAGES by the use of overvoltage limiting devices

TRANSIENT OVERVOLTAGES in a circuit may be limited by combinations of circuits or components. Components suitable for this purpose include varistors and gas-filled surge arrestors.

If the overvoltage limiting device or circuit is intended to reduce TRANSIENT OVERVOLTAGES so that the circuit following it may have reduced CLEARANCES, a RISK assessment (see Clause 17) shall be performed, taking into account both of the following aspects:

a) the circuit shall reduce TRANSIENT OVERVOLTAGES to the lower level even under SINGLE FAULT CONDITIONS;
b) the circuit shall operate as intended even after withstanding repeated TRANSIENT OVERVOLTAGES.

Conformity is checked by evaluation of the RISK assessment documentation to ensure that the RISKS have been eliminated or that only TOLERABLE RISKS remain.

Annex L
(informative)

Index of defined terms

This annex of IEC 61010-1:2010 does not apply.

See IEC 61010-1:2010, Clause 1 and Clause 3 of this document for a complete set of defined terms.

Annex AA
(informative)

General approach to safety for control equipment

AA.1 Personnel

AA.1.1 General

There are two types of persons whose safety it is necessary to consider, OPERATORS and SERVICE PERSONNEL. Figure AA.1 depicts the general situation.

NOTE SERVICE PERSONNEL is described in Clause 3.

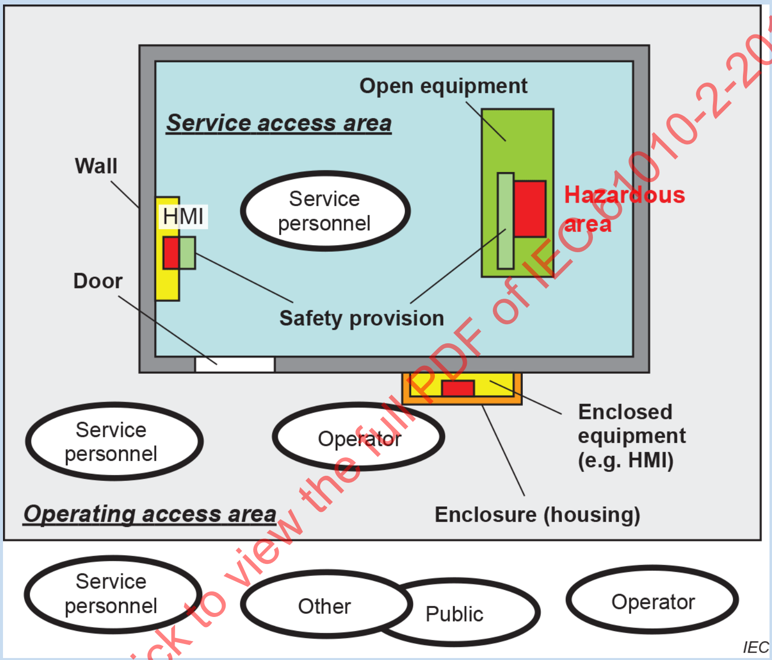


Figure AA.1 – Control equipment access and safety concerns

AA.1.2 OPERATOR

OPERATOR is the term applied to all persons other than SERVICE PERSONNEL. Requirements for protection should assume that OPERATORS are not trained to identify HAZARDS, but will not intentionally create a hazardous situation. Consequently, the requirements will provide protection for cleaners and casual visitors as well as the assigned OPERATORS. In general, OPERATORS should not have access to hazardous parts, and to this end, such parts should only be in service access areas or in ENCLOSED EQUIPMENT located in operating access areas.

AA.1.3 SERVICE PERSONNEL

SERVICE PERSONNEL are expected to use their training and skill to avoid possible injury to themselves and others due to obvious HAZARDS that exist in service access areas of the control equipment or on ENCLOSED EQUIPMENT located in operating access areas. However, SERVICE PERSONNEL should be protected against unexpected HAZARDS.

This may be done by, for example:

- locating parts that require to be ACCESSIBLE for servicing away from areas with electrical and mechanical HAZARDS;

- providing shields to avoid accidental contact with hazardous parts;
- providing interlocks as protection against HAZARDS;
- providing labels or instructions to warn personnel about any residual RISK.

Information about potential HAZARDS may be marked on the control equipment or provided with the control equipment, depending on the likelihood and severity of injury, or made available for SERVICE PERSONNEL. In general, OPERATORS shall not be exposed to HAZARDS likely to cause injury, and information provided for OPERATORs should primarily aim at avoiding misuse and situations likely to create HAZARDS, such as connection to the wrong power source and replacement of fuses by incorrect types.

There can be requirements for SERVICE PERSONNEL to be licensed or certified for the equipment they service.

AA.2 Operating access areas

This is meant as the control equipment location. SERVICE PERSONNEL have access to these areas and OPERATORS may be allowed depending on the level of training or instruction necessary for access. This can be a room or a cabinet, for example.

AA.3 Service access areas

These are areas of the control equipment where service tasks are expected to be performed, i.e. changing fuses, batteries, cleaning filters, performing isolation tests. Only SERVICE PERSONNEL have access. This can be a room or a cabinet, for example. These areas are normally secured.

AA.4 Equipment types

AA.4.1 General

Two types of control equipment are available. These have different constructional requirements. These are meant for use by different personnel or installation, or both, in different areas. These two control equipment types are OPEN and ENCLOSED EQUIPMENT.

AA.4.2 OPEN EQUIPMENT

OPEN EQUIPMENT is meant for access only by SERVICE PERSONNEL. It provides protection for SERVICE PERSONNEL against unintentional contact with:

a) unexpected HAZARDOUS LIVE parts;
b) unexpected hot surfaces, as opposed to expected hot surfaces such as heat sinks and semiconductors;
c) unexpected mechanical HAZARDS, such as sharp edges, protruding wires and screws, as opposed to expected mechanical hazards such as fans.

AA.4.3 ENCLOSED EQUIPMENT

ENCLOSED EQUIPMENT is meant for access by an OPERATOR. It provides protection for the OPERATOR in NORMAL CONDITION and SINGLE FAULT CONDITION against:

a) contact with HAZARDOUS LIVE parts;

b) hot surfaces;

c) mechanical HAZARDS.

NOTE The ENCLOSURE can be used to prevent spread of fire, from the ENCLOSED EQUIPMENT, if the ENCLOSURE is designed for that purpose.

Annex BB
(informative)

System drawing of isolation boundaries

BB.1 General

The intent of Annex BB is to foster a consistent use of this document by designers and certifiers.

One concept discussed is a kind of system drawing, which can be used to understand and communicate the electrical safety and isolation in a system as it is developed. This drawing can then help inform future designers and certification parties, working on the system, of the concepts originally set down.

This annex will focus on OPEN EQUIPMENT. The figures shown in this annex are examples and serve for illustration of the text.

The following pictures in this annex only deal with electric shock aspects.

BB.2 Installation environment of OPEN control equipment

Figure BB.1 depicts an example of a typical ENCLOSURE. The ENCLOSURE contains multiple items which comprise parts of the overall automation system.

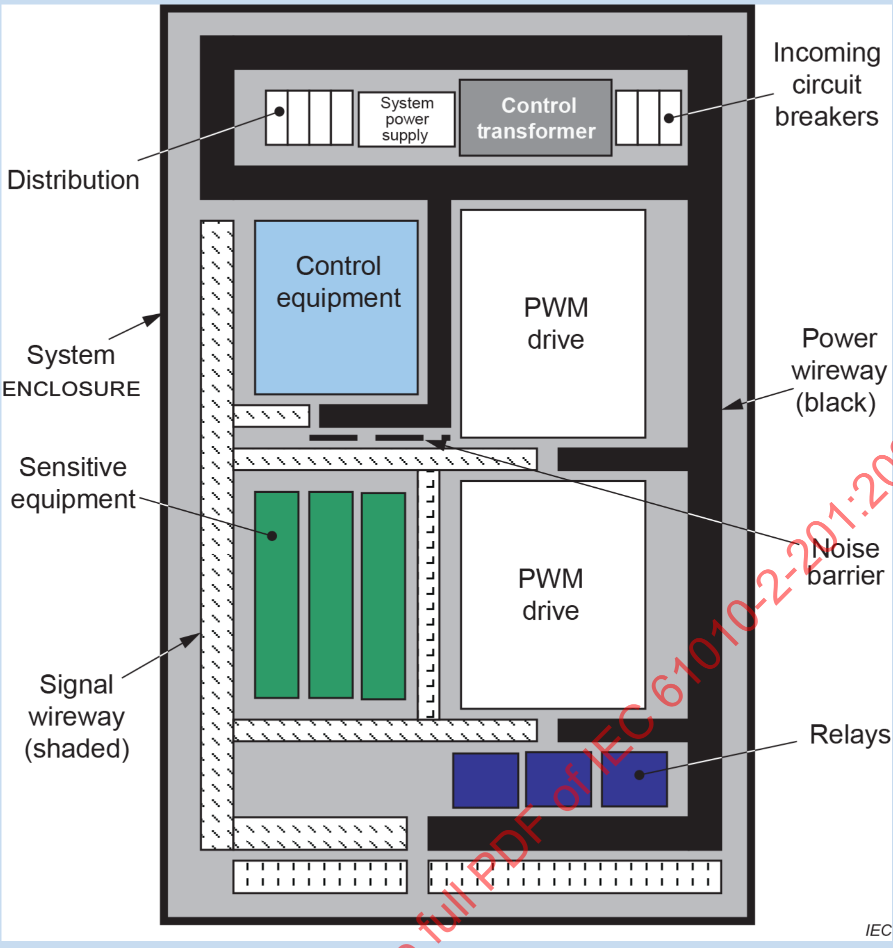


Figure BB.1 – Typical system ENCLOSURE layout

The incoming circuit breakers are shown near the top of the ENCLOSURE. This may be the factory three-phase distribution a.c. power, for example 480 V a.c.. Next to this is a control transformer illustrated. This is used to step down the factory power to local control power, for example 480 V a.c. three phase to single phase 120 V a.c..

The system power supply, which utilizes the local control power to provide control equipment power, for example 24 V d.c. is located to the left of the control transformer. Located close by these items, would be power distribution circuit breakers and TERMINALS so as to distribute the local control and control equipment power within the ENCLOSURE. Note these items are normally located near the top of the ENCLOSURE to keep their heat production from affecting more heat sensitive equipment below.

Located on the right side of the ENCLOSURE are a set of PWM drives, which are not the subject of this document, see the IEC 61800 series. However it is typical to see such an automation system configuration.

More sensitive equipment (sensitive from a temperature or of EMC noise perspective, or both) is normally located near the bottom of the ENCLOSURE.

The subject of this document, control equipment, is located at the left centre. It is more temperature and noise tolerant, but not as insensitive as those items near the top of the ENCLOSURE.

Note the wireway organization. It is laid out to segregate wiring by type; for example high power, higher voltage, noise prone wiring in the black wireway and low power, low voltage, low noise wiring in the shaded wireway. Note also the noise barrier where it is necessary for high power/noise and low power/noise wiring to be in close proximity.

BB.3 Control equipment electrical safety drawing

Utilizing the general layout just discussed, and focusing on the control equipment, it is possible to create a generalized schematic of the environment in which the control equipment resides. Figure BB.2 represents an example schematic for what can be called a control equipment electrical safety drawing.

This diagram can provide a key item in the design of any control system, the environment and the method by which that system will achieve protection against electrical shock hazards.

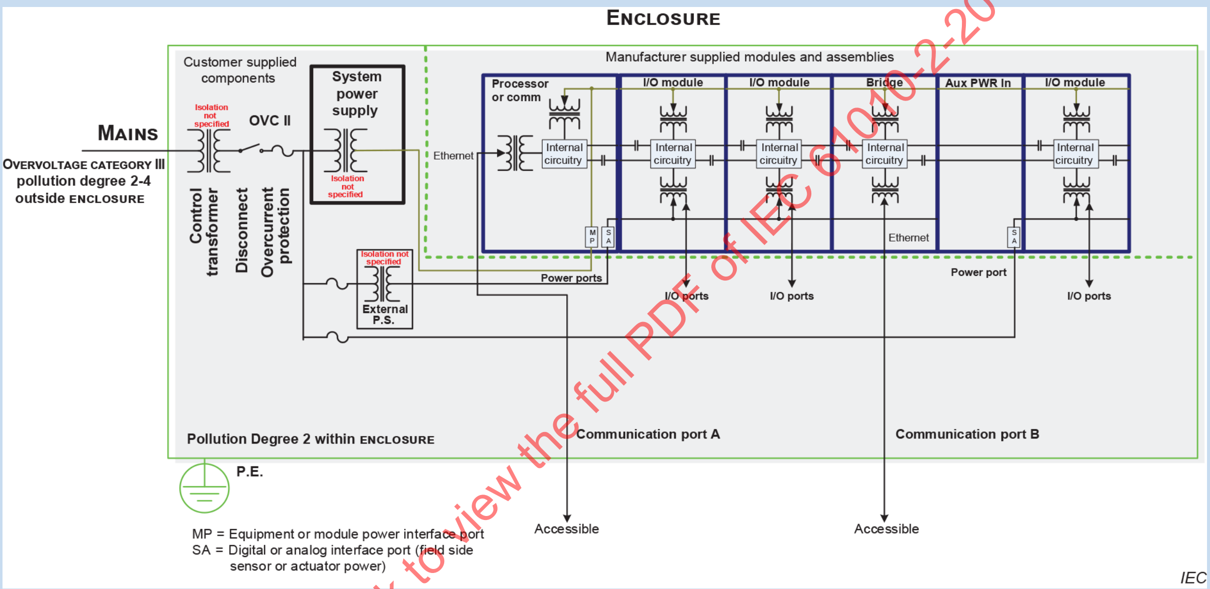


Figure BB.2 – Simplified system schematic

The control equipment, which is being discussed, is within the dashed green box and referred to as "manufacturer supplied modules and assemblies". This is the equipment being designed with the help of this document. As this example is a modular system, a number of example modules, for example processor or communication module, I/O module, bridge (another type of communication module) and a power input module are shown. Many other types of modules are possible. See Figure 101.

Since this example is OPEN EQUIPMENT, it is shown housed inside the ENCLOSURE. This is generally a larger ENCLOSURE into which many different equipment items are housed. See Figure BB.1.

The two lines exiting the ENCLOSURE, IN Figure BB.2 to Figure BB.11, are communications lines normally ACCESSIBLE by personnel, for example OPERATORS, or interfaced to other equipment, for example PWM drives. As these items can be ACCESSIBLE by OPERATORS, protection is provided. See communication ports for example Ar, Be or E in Figure 101 and Table 101.

Each of the modules, for example processor or communication module, I/O module, bridge or auxiliary power input module, may have other ports where connection is made to the module.

I/O ports are shown in the schematic, for example C or D in Figure 101 and Table 101. And power ports are also shown, for example F or J in Figure 101 and Table 101.

At the top of each module a transformer is shown. This is used to schematically indicate isolation between power entering at the top and the "internal circuitry" fed from the transformer. Similarly at the bottom of the side of each module is another transformer symbol. Again this indicates the isolation between the "internal circuitry" and the power and circuitry which may be on the opposite side.

"Internal circuitry" is that circuitry, for example microprocessor or memory, which is internal to the module and sits inside a sort of isolation island formed by the indicated transformers. Hence it can be said the internal circuitry is isolated from the outside world.

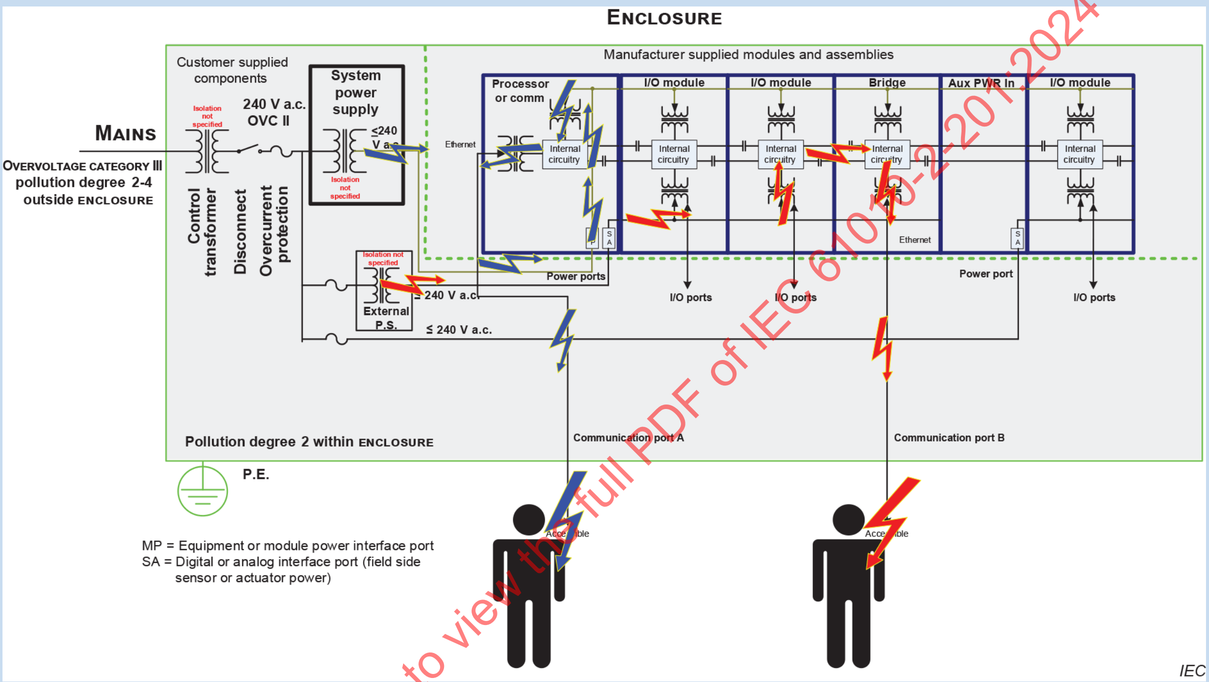


Figure BB.3 – HAZARD situation of the control equipment

Figure BB.3 depicts two example situations for the safety aspects provided in Figure BB.2.

Following the blue lightning bolts, representing a hazardous voltage, the voltage is shown entering a power port. If there are failures of the processor module isolation devices or they do not exist, then the person working on the communication port A will be exposed to the hazardous voltage.

Similarly, again referring to Figure BB.3, following the red lightning bolts, also representing a hazardous voltage, the voltage is shown entering a different power port. If there are failures of the I/O module and bridge isolation devices or they do not exist, then the person working on the communication port B will be exposed to the hazardous voltage.

BB.4 Applying IEC 61010-2-201 to the control equipment electrical safety drawing

Figure BB.4, Figure BB.5 and Figure BB.6 provide a reference for establishing which clauses of this document apply to which areas of the control equipment electrical safety drawing.

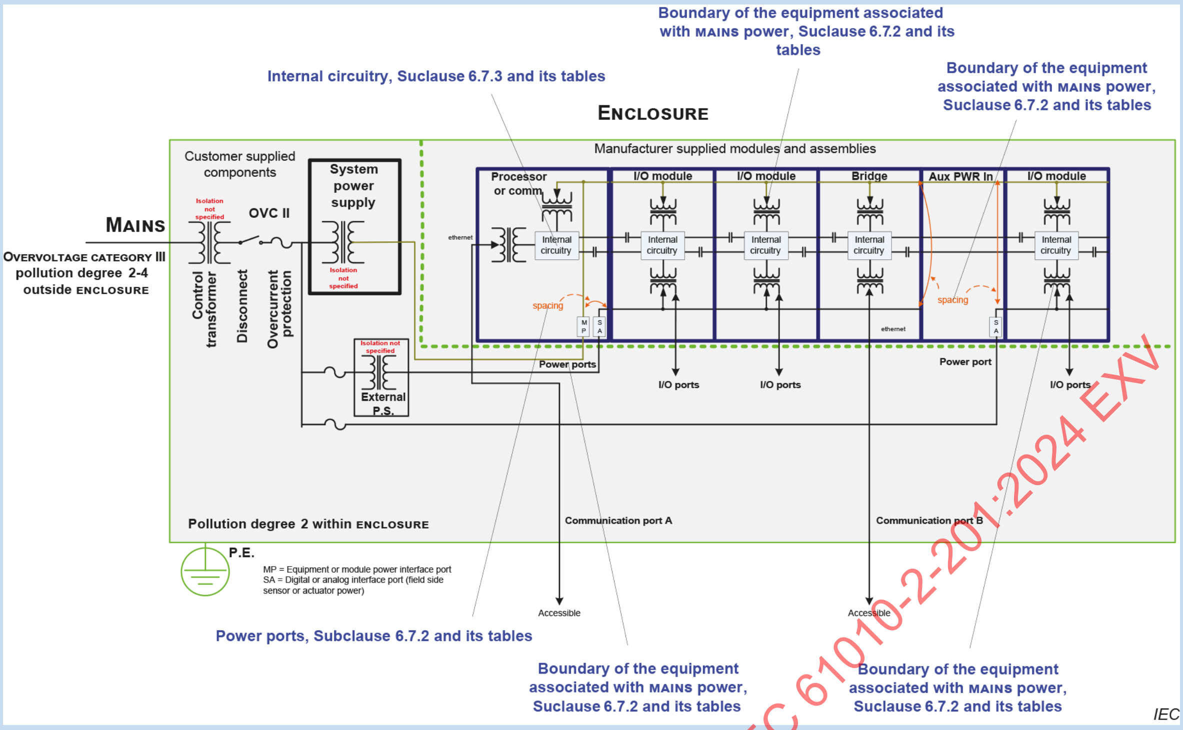


Figure BB.4 – Application of IEC 61010-2-201 to the control equipment safety drawing

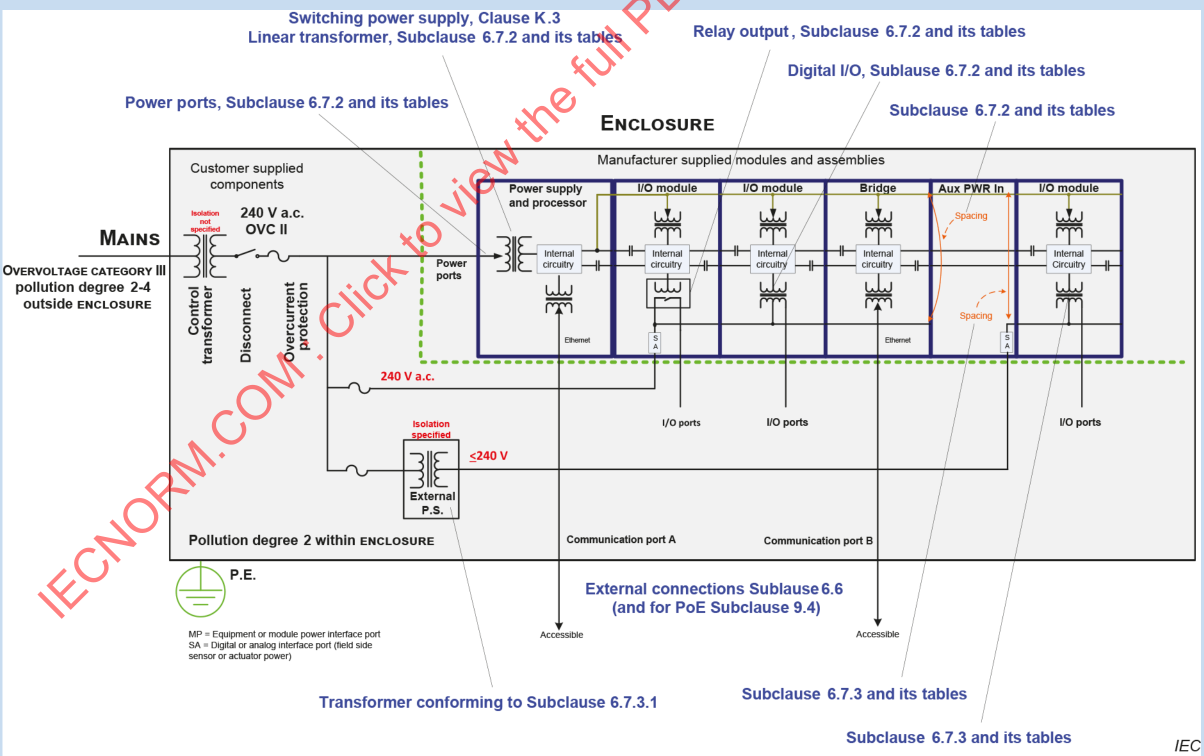


Figure BB.5 – Application of 6.7.1.5 items a) and b) to the control equipment safety drawing

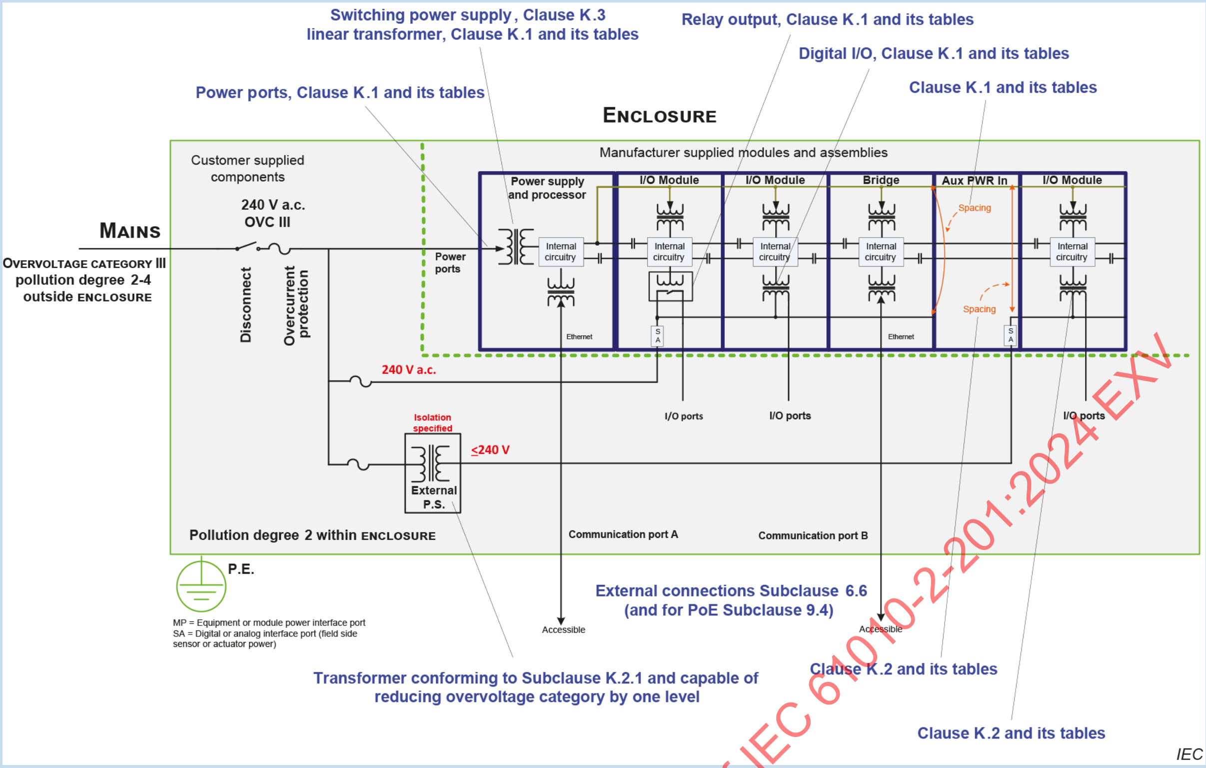


Figure BB.6 – Application of 6.7.1.5 items a), b), c) and d) to the control equipment safety drawing

For this document, the equipment shall be safe under normal and SINGLE FAULT CONDITION. Some examples of different methodologies to make the schematic in Figure BB.3 safe are now presented.

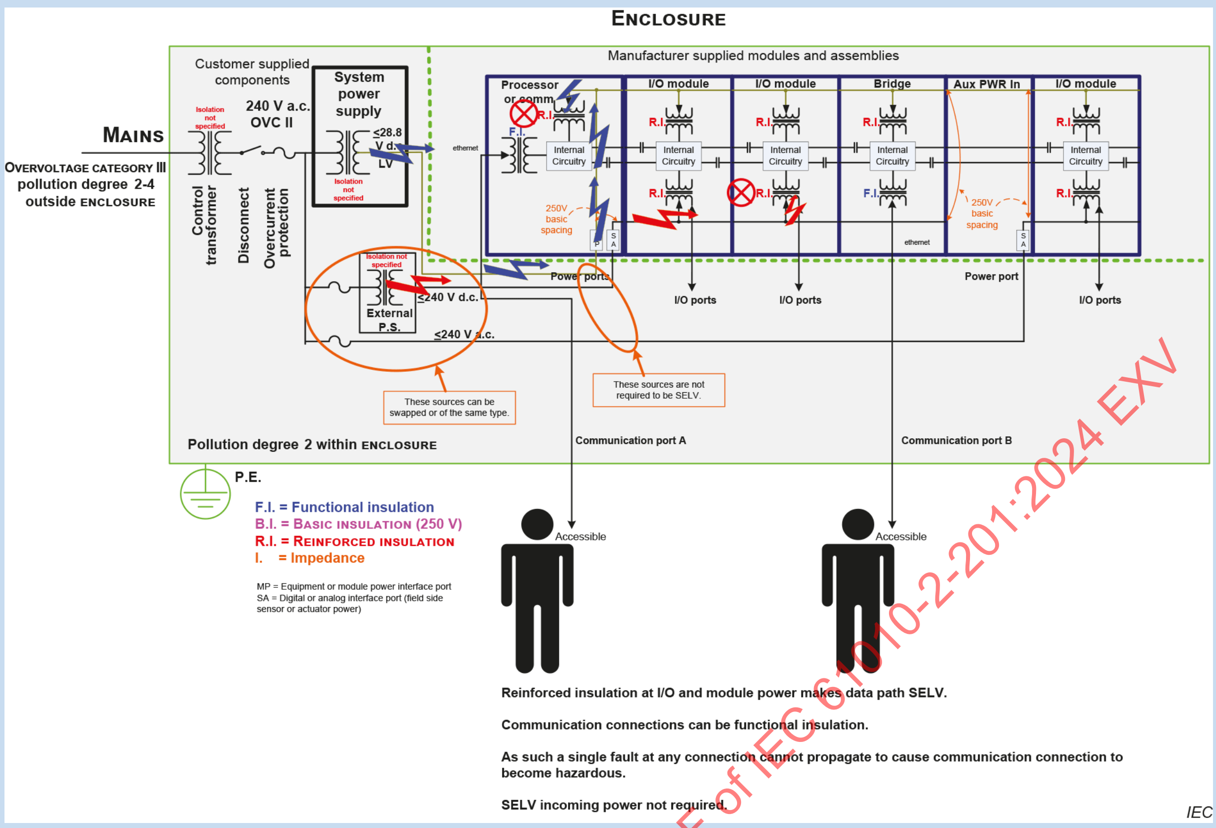


Figure BB.7 – REINFORCED INSULATION

Referring to Figure BB.7, REINFORCED INSULATION provides the method to handle single faults and maintain safety.

REINFORCED INSULATION at I/O and module power makes the ACCESSIBLE communication ports SELV/PELV.

Communication connections can utilize functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

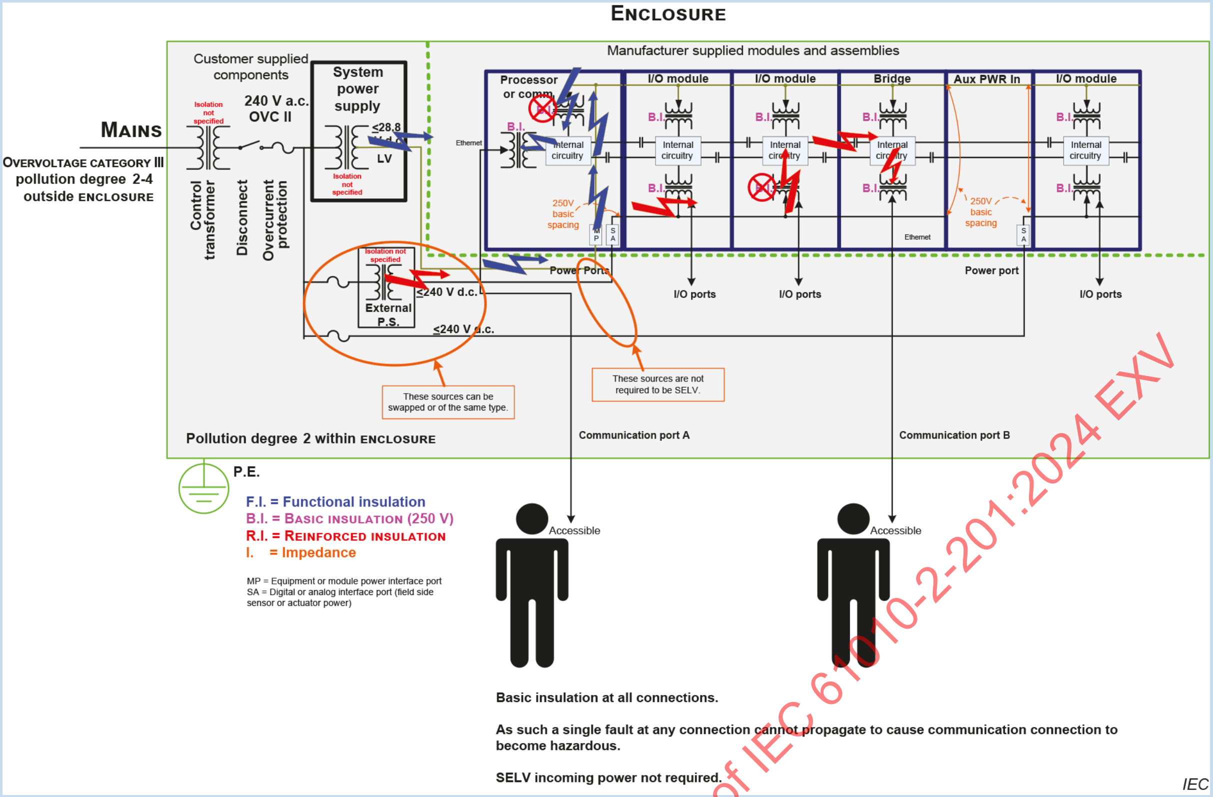


Figure BB.8 – BASIC INSULATION

Referring to Figure BB.8, BASIC INSULATION provides the method to handle single faults and maintain safety.

BASIC INSULATION is provided at all connections. One failure of a BASIC INSULATION is allowed, but a second level of BASIC INSULATION is always present.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

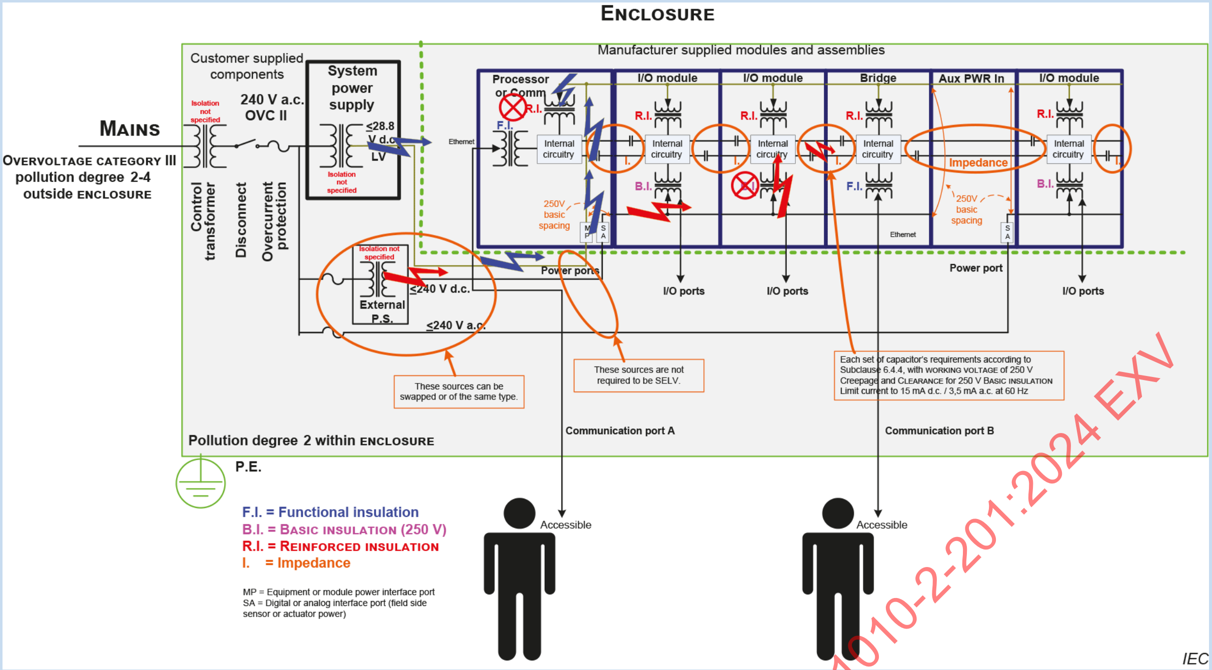


Figure BB.9 – REINFORCED INSULATION, BASIC INSULATION and impedance

Referring to Figure BB.9, REINFORCED INSULATION, BASIC INSULATION and impedance provide the method to handle single faults and maintain safety.

REINFORCED INSULATION is provided at module power. Impedance, by inter-module capacitors, and basic (supplementary) insulation is provided at the I/O.

Communication connections can be functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

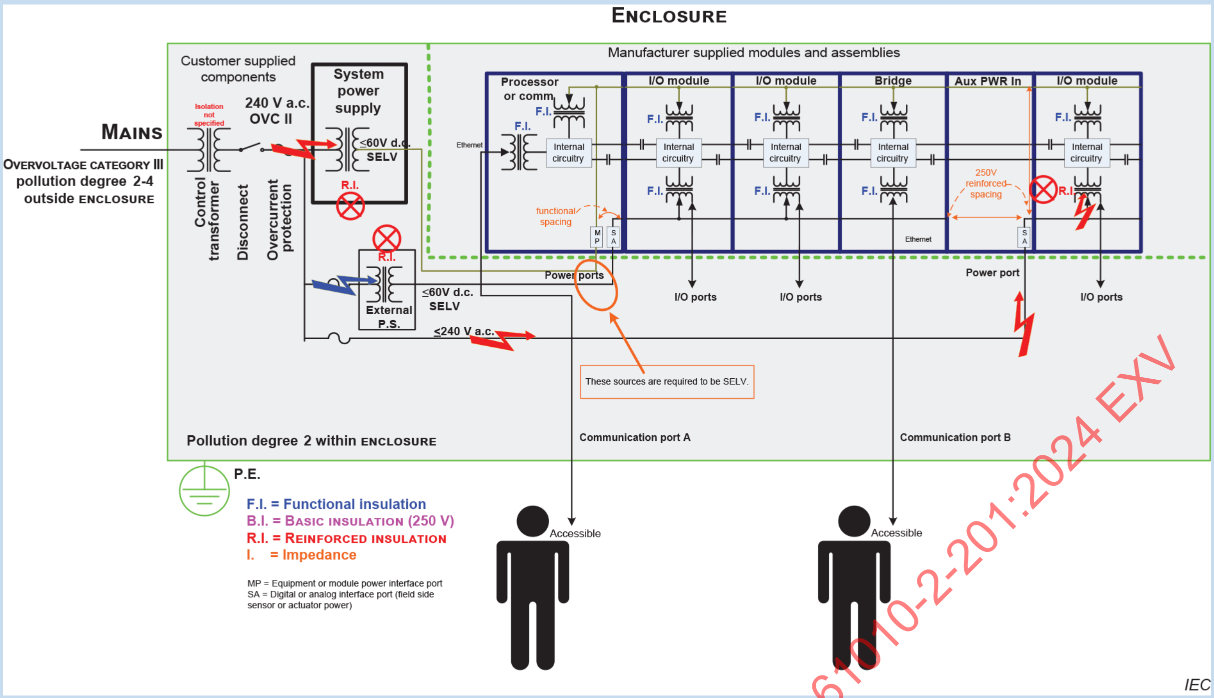


Figure BB.10 – REINFORCED INSULATION from external power supplies

Referring to Figure BB.10, external power supplies provide REINFORCED INSULATION with SELV/PELV output levels and hence provide the method to handle single faults and maintain safety.

I/O, communication connections can be functional insulation, as they are not required to provide any protection.

REINFORCED INSULATION is necessary wherever any non-SELV/PELV power is applied, for example a.c. I/O.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

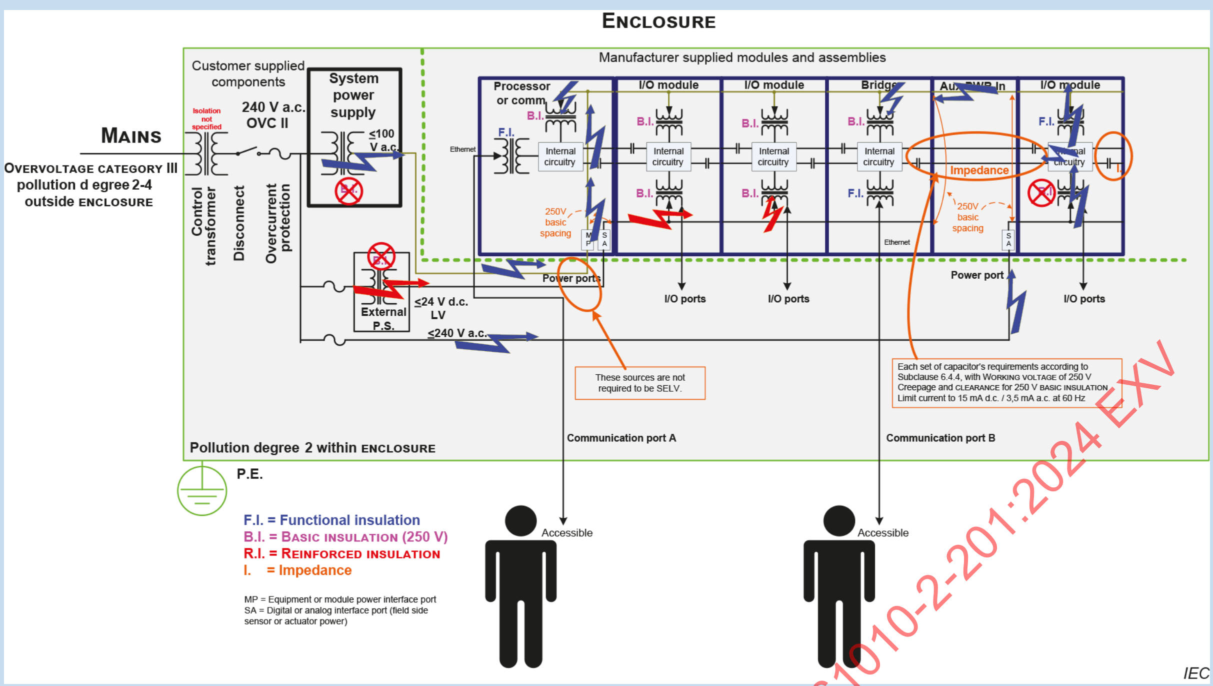


Figure BB.11 – BASIC INSULATION from external power supplies

Referring to Figure BB.11, external power supplies provide BASIC INSULATION and hence provide a method to handle single faults and maintain safety.

BASIC INSULATION is also provided at all connections I/O. One failure of a BASIC INSULATION at the power supplies is allowed, but a second level of BASIC INSULATION is always present, at the I/O.

Impedance, by inter-module capacitors, and BASIC INSULATION can also be provided at the I/O. In this way a first failure is protected against.

Communication connections can be functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

These five scenarios are just a few of many which may be the basis for control system electrical safety.

Whatever the method chosen, it is recommended the method be documented in a drawing, such as shown here.

BB.5 Conclusion

The development of a control equipment electrical safety drawing is invaluable in understanding and communicating the electrical safety and isolation in a system as it is developed. This can keep all parties involved in the original certification, as well as future participants making additions to an expandable system, on a consistent path.

Annex CC
(informative)

Historical techniques for secondary circuits

CC.1 Secondary circuits background

Annex CC is meant to describe a set of circuits utilized historically in control equipment. These techniques are not recommended for new designs. Newer techniques have been devised and accepted into common practice eliminating the need for these circuits.

This annex is an overview and is not meant to be a complete description of these circuits, the techniques nor the requirements and conditions to utilize them. For a complete set of information on these circuits, see UL 508.

The circuits listed offer two areas of effect: controlling the provisions against electric shock and against spread of fire.

CC.2 Secondary circuits without RISK of electrical shock

CC.2.1 General

The following secondary circuits also do not pose a RISK of electrical shock and do not require additional evaluation for RISK against electrical shock:

a) class 2 circuit;
b) circuits with limited voltage and current (limited voltage/current circuits);
c) limited voltage circuit;
d) limited energy circuit that involves open circuit potential less than or equal to 30 V a.c. or 42,4 V peak;
e) limiting impedance circuit.

These circuits are described in CC.2.2.1, CC.2.2.2, CC.2.2.3, CC.2.2.4 and CC.2.2.5.

CC.2.2 Secondary circuits which do not pose a RISK of electrical shock

CC.2.2.1 Class 2 circuit

A class 2 circuit shall be supplied by an isolating source, providing DOUBLE INSULATION or REINFORCED INSULATION, which has a maximum output voltage of 42,4 V peak (sinusoidal or non-sinusoidal a.c.) or 60 V for continuous d.c. or 24,8 V peak for d.c. interrupted at a rate of 200 Hz or less with approximately 50 % duty cycle.

The maximum output current of a class 2 source depends on whether it is inherently limited or not inherently limited. For inherently limited sources, Table CC.1 applies. For not inherently limited sources, Table CC.2 applies.

CC.2.2.2 Limited voltage/current circuit

A circuit with limited voltage and current (limited voltage/current circuit) shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, in such a way that the maximum open-circuit voltage available to the circuit is not more than a.c. 30 V RMS and 42,4 V peak and the current available is limited to a value not exceeding 8 A measured after 1 min of operation.

The secondary winding of an isolating type transformer may be used to comply with this requirement.

A secondary fuse or other such secondary circuit protective device used to limit the available current shall be RATED at no more than 5,0 A for a circuit RATED less than, or equal to, 20 V peak, or 100 VA for a circuit RATED from 20 V to 30 V peak.

If the current-limiting device is provided in the MAINS CIRCUIT, there are no restrictions on its current RATING as long as it limits the available secondary current to 8 A.

CC.2.2.3 Limited voltage circuit

A limited voltage circuit shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, with a maximum open-circuit voltage of not more than a.c. 30 V RMS and 42,4 V peak without any limitation on the available current or volt-ampere capacity.

Overcurrent protection shall be provided to protect against burnout and damage to the insulation resulting from any overload or short-circuit condition. This protection may alternately be provided in the MAINS CIRCUIT by overcurrent protective devices provided with the control equipment or by branch circuit devices.

CC.2.2.4 Limited energy circuit which involves open-circuit potential less than, or equal to, a.c. 30 V RMS and 42,4 V peak

A limited energy circuit shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, in such a way that the maximum volt-ampere capacity available to the circuit is 200 VA or less at a maximum open-circuit voltage of less than or equal to a.c. 30 V RMS and 42,2 V peak. The secondary winding of an isolating type transformer may be used to comply with this requirement. A primary or secondary fuse or other circuit protective device may be used to limit the maximum volt-ampere capacity.

CC.2.2.5 Limiting impedance circuit

A limiting impedance circuit shall be supplied by an impedance that complies with the following two requirements:

a) the calculated power dissipation of the impedance, as the result of a direct short applied across the circuit downstream of the impedance, does not exceed the power RATING of the impedance, and
b) the power dissipated in the impedance shall be less than 15 W.

If the above calculated power dissipation exceeds the RATING of the impedance, the impedance may still be used if the power is less than 15 W and if the impedance does not open or short when subjected to a direct short applied across the circuit downstream of the impedance.

The limiting impedance shall be able to function under SINGLE FAULT CONDITION unless the circuit limited by the impedance is enclosed.

A single resistor, or a single across-the-line capacitor approved per 14.101.1, is considered to comply with this limiting impedance requirement.

CC.3 Secondary circuits without RISK of spread of fire

CC.3.1 General

The following secondary circuits also do not pose a RISK of spread of fire and do not require additional evaluation for RISK of spread of fire:

a) class 2 circuit;

b) limited voltage/current circuit;

c) limiting impedance circuit;

d) limited power circuit.

CC.3.2 Secondary circuits which do not pose a RISK of spread of fire

CC.3.2.1 Class 2 circuit

See CC.2.2.1.

CC.3.2.2 Circuit with limited voltage and current (limited volage/current circuit)

See CC.2.2.2.

CC.3.2.3 Limiting impedance circuit

See CC.2.2.5.

CC.3.2.4 Limited power circuit

A limited power circuit is a circuit supplied by sources such as a battery or a transformer winding where the open-circuit potential is not more than a.c. 30 V RMS and 42,4 V peak or d.c. 60 V, and the energy available to the circuit is limited according to one of the following means:

a) the maximum output current and power are inherently limited to not more than the values of Table CC.1;

b) the maximum output current under all conditions and power are limited by impedance to be not more than the values of Table CC.1;

c) an over-current protective device limits the maximum output current and power to not more than the values of Table CC.2;

d) a regulating network limits the maximum output current and power to not more than the values of Table CC.1 in NORMAL USE or as a result of one fault in the regulating network; or

e) a regulating network limits the maximum output current and power to not more than the values of Table CC.1 in NORMAL USE, and an over-current protective device limits the output current and power to not more than the values of Table CC.2 as the result of any one fault in the regulating network.

Where an over-current protective device is used, it shall be a fuse or a non-adjustable non-self-resetting device.

Table CC.1 – Limits of output current and output power for inherently limited power sources

Open-circuit output voltage *U*		Maximum output current	Maximum output power
a.c. V RMS	d.c. V	A	VA
≤ 20	≤ 20	8,0	5 × *U*
20 < *U* ≤ 30	20 < *U* ≤ 30	8,0	100
	30 < *U* ≤ 60	150/*U*	100

For non-sinusoidal a.c. and for d.c. with ripple exceeding 10 %, the peak voltage shall not exceed 42,4 V peak.

Table CC.2 – Limits of output current, output power and RATINGS for over-current protective devices for non-inherently limited power sources

Open-circuit output voltage *U*		Maximum output current	Maximum output power	RATED current value of over-current protective device
a.c. V RMS	d.c. V	A	VA	A
≤ 20	≤ 20	1 000/*U*	250	≤ 5
20 < *U* ≤ 30	20 < *U* ≤ 60	1 000/*U*	250	≤ 100/*U*

RATED current values for over-current protective devices are for fuses and circuit-breakers which break the current within 120 s at a current value of 210 % of the value in the last column of Table CC.2.

Conformity is checked by measuring the output voltage, the maximum output current and the maximum available output power under the following conditions:

1) *output voltage is measured in no-load condition;*
2) *output current and available power are measured after 60 s of operation, with any over-current protective devices short-circuited, with a resistive load (including short-circuit) which produces the highest value of current and power respectively.*

Annex DD
(normative)

Flammability test for magnesium alloy fire ENCLOSURES or flame barriers (see 9.3.2)

DD.1 General

When magnesium alloy is used as a fire ENCLOSURE or a flame barrier, the flammability properties shall be determined to support the requirements of 9.3.2. The method described in Annex DD will demonstrate whether the material will ignite under typical conditions, and whether the flame, if it does ignite, will propagate long enough to cause a HAZARD of the spread of fire.

This method is similar to the method used for determining the flammability characteristics of plastics.

NOTE The test methods and conformance criteria of the 500 W vertical burning test for plastic materials of ANSI/UL 94 are equivalent.

Conformity is checked as specified in Clause DD.2 to Clause DD.5. During the test and until 1 min after the last application of the test flame, the sample shall not ignite.

DD.2 Samples

One sample is tested, consisting of a complete fire ENCLOSURE or flame barrier.

DD.3 Mounting of samples

The sample is mounted and oriented as it would be in actual use.

DD.4 Test flame

The 500 W nominal test flame of IEC 60695-11-3 shall be used.

DD.5 Test procedure

The test flame is applied to an inside surface of the sample at a minimum of three points and a maximum of five points, including the section of the sample where the material is the thinnest, sections of the sample where ventilation or other openings are located, and sections of the sample that are located near a source of ignition. If it is not possible to apply the flame to the inside surface, it may be applied to the outside surface.

If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical. If ventilation or other openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the inner blue cone of the flame shall be in contact with the sample.

The flame is applied to each point for 5 s, removed for 5 s, then reapplied again to the same point until a total of five applications have been made to this point. After that, the flame is removed for 60 s, and then applied in the same manner to the next test point on the sample.

Annex EE
(informative)

Information and documentation and correlation to their uses

Annex EE is not a certification requirement. It is included only to depict one of many examples of how industrial components are combined together to form a useful application. Other industries have a similar or the same workflow.

This example focuses on how information and documentation, regarding safety aspects, might flow through the development process of that useful application.

As shown in Figure EE.1, component products are generally combined together with other products to execute some useful application. As such, the information and documentation has more of an installer, service, system designer focus rather than an end use focus and need.

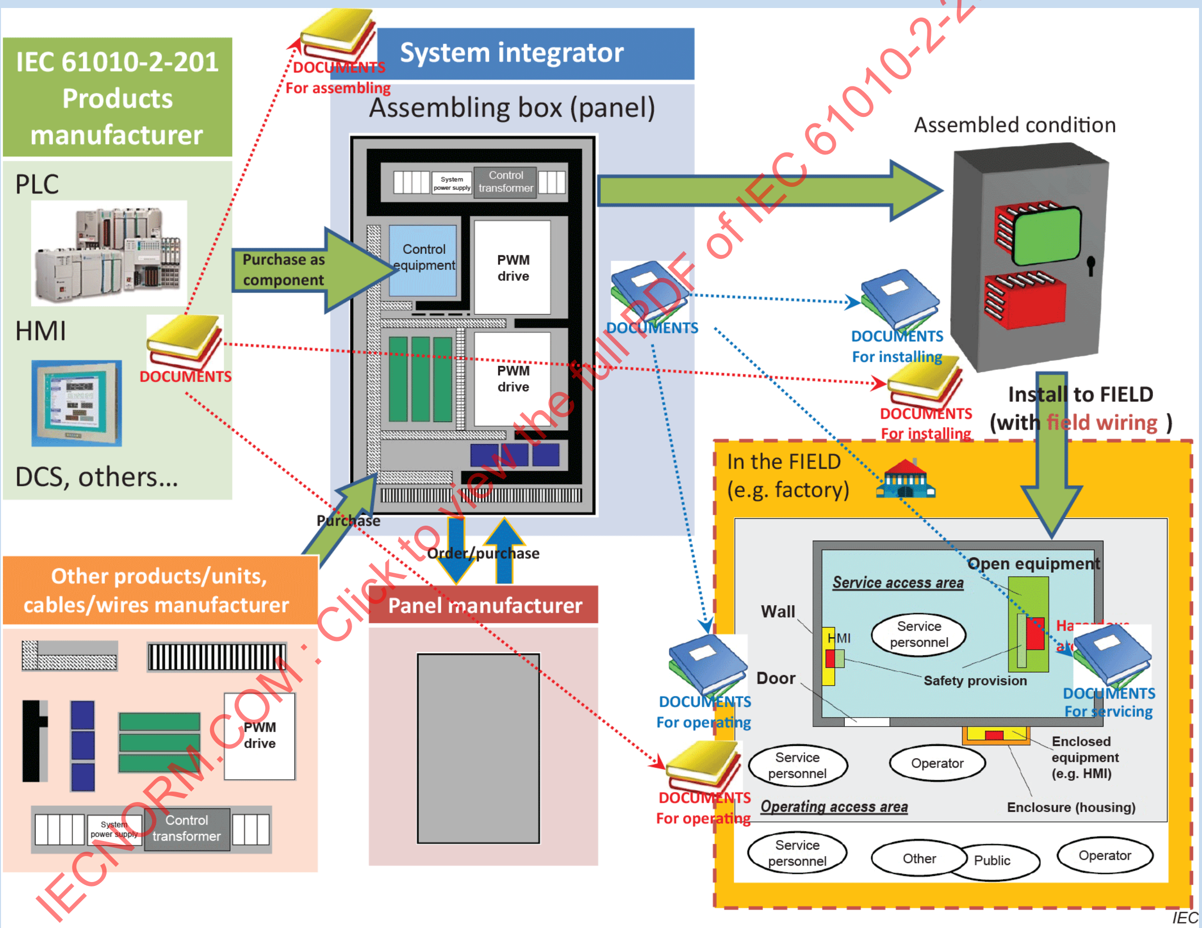


Figure EE.1 – Information and documentation for component products

Figure EE.2 shows an example of safety information as it is collected, selected and differentially compiled for different end uses, with regard to certain installations.

On the left are the documentation sets provided by the component manufacturers. These may include safety information (the focus in the example), programming information, specification information, end-of-life recycling information, warranty information, etc.

Moving to the right, those components may next be utilized by panel manufacturers to build their part of the overall installation. The panel manufacturers can select parts of the information from each of the component manufacturers to include in their safety information. The panel manufacturers can reformat, include and pass on this information along with their own panel safety information.

At the next stage, a system integrator selects, reformats, and passes on the relevant safety information which the system owner requested or the integrator feels the owner will require.

Lastly, the system owner may then again partition the information targeted to the OPERATORS and maintenance people.

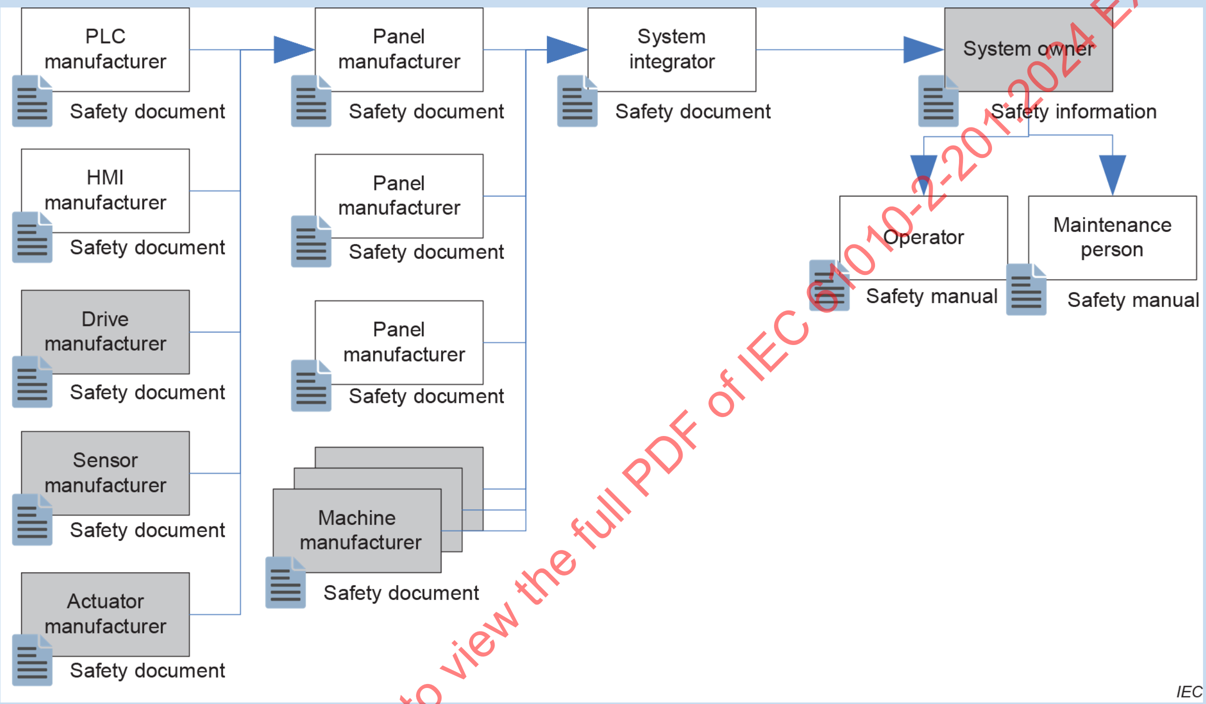


Figure EE.2 – Information and documentation accumulation and segregation tree for an example installation

This is one on many ways information and documentation of various types, threads its way from the manufacturer to the OPERATORS, maintenance personnel, etc.

Annex FF
(informative)

Measurement of CLEARANCES and CREEPAGE DISTANCES

The following examples complement those examples given in IEC 61010-1:2010, Annex C.

These examples are presented to enhance explanation of situations commonly found in control equipment. Very often they occur in the cases where surface mount devices (SMD) are utilized on printed wiring boards (PWBs). SMD devices present situations where there can be minimal or no distance between a component and the PWB. This brings into focus the question of which CLEARANCE and CREEPAGE rules apply with regard to the component of some material group (MG) and the PWB when the distance between component and PWB shrinks to minimal values.

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are indicated in the following Figure FF.1 and Figure FF.2. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

a) where the distance across a gap is equal to or larger than *X* (see Table FF.1), the CREEPAGE DISTANCE is measured along the contours of the body of the component (see Figure FF.1);

b) any recess is assumed to be bridged with an insulating link having a length equal to *X* and being placed in the least favourable position (see Figure FF.2);

c) CLEARANCES and CREEPAGE DISTANCES measured between parts which can assume different positions in relation to each other are measured when these parts are in their least favourable position.

In the following examples dimension *X* has the value given in Table FF.1 depending on the POLLUTION DEGREE.

Table FF.1 – Dimensions of *X*

POLLUTION DEGREE	Dimension *X* mm
1	0,25
2	1,0
3	1,5

If the associated CLEARANCE is less than 3 mm, the dimension *X* in Table FF.1 may be reduced to one-third of this CLEARANCE.

The MG of the various surfaces shall be taken into consideration.

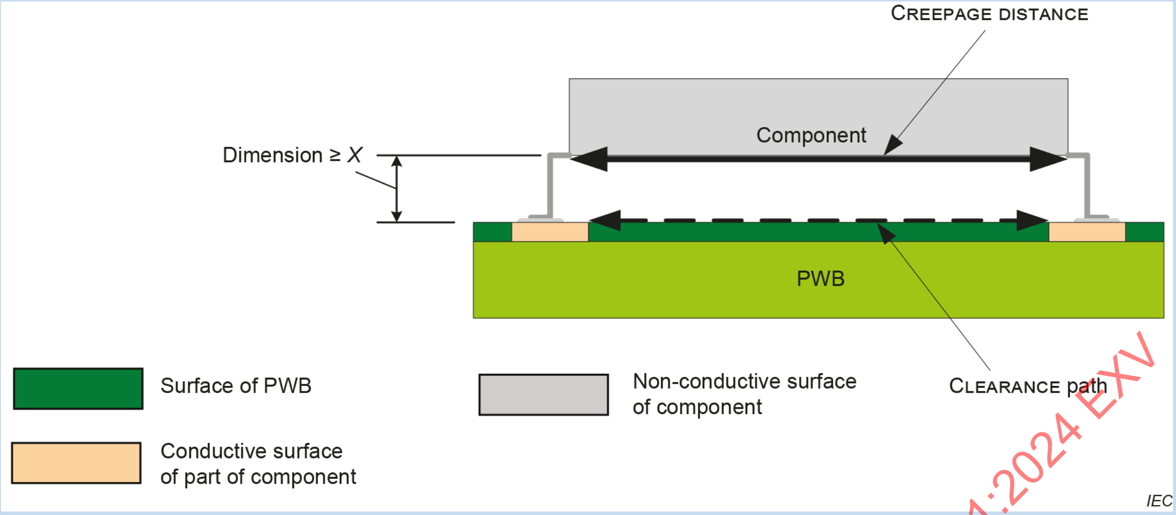


Figure FF.1 – Path of a component mounted to a PWB (side view)

EXAMPLE 1 Figure FF.1

The CLEARANCE is the shortest direct air path across the top of the PWB.

The CREEPAGE DISTANCE follows the contour of the component, along the shortest path measured on any side of the component.

NOTE 1 When components have a lower MG value than the surface on which they are mounted, the critical distance can be along the surface of the component. If the surface of the component and the surface on which it is mounted have the same MG, the critical CREEPAGE DISTANCE can be the direct path along the surface of the PWB.

NOTE 2 The conductive contacts on a component can be positioned such that the shortest path can be above or beside the component, and not necessarily below the component as shown.

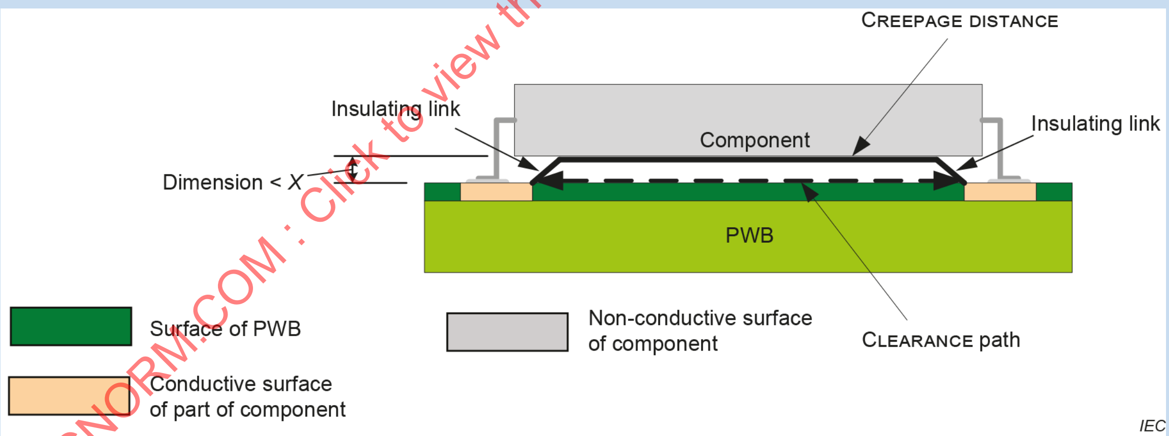


Figure FF.2 – Path of a component mounted to a PWB (side view)

EXAMPLE 2 Figure FF.2

The CLEARANCE is the shortest direct air path across the top of the PWB.

The CREEPAGE DISTANCE follows the insulating links to the contour of the bottom of the component.

NOTE 3 The measurement across the surface of the component starts where the link distance, value from Table FF.1, starting from the conductive contacts meets the surface of the component and continues to where the link distance from the opposite conductive contact meets the surface of the component.

NOTE 4 The conductive contacts on a component can be positioned such that the shortest path can be between these two contacts, or between one conductive contact and the conductive surface on the PWB, and not always between the two conductive surfaces on the PWB surface.

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IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test*

IEC 60715, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60721-2-3, *Classification of environmental conditions – Part 2-3: Environmental conditions appearing in nature – Air pressure*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60950 (all parts), *Information technology equipment – Safety*

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

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

IEC 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Special requirements for testing and measuring circuits*

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

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

IEC 61131 (all parts), *Programmable controllers*

IEC 61131-2:2017, *Industrial-process measurement and control – Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61131-6, *Programmable controllers – Part 6: Functional safety*

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61243-3, *Live working – Voltage detectors – Part 3: Two-pole low-voltage type*

IEC 61326 (all parts), *Electrical equipment for measurement, control and laboratory use – EMC requirements*

IEC 61508 (all parts), *Functional safety of electrical electronic/programmable electronic safety-related systems*

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

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[1] Withdrawn.

IEC 61643 (all parts), *Low-voltage surge protective devices*

IEC 61643-21, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61643-311, *Components for low-voltage surge protective devices – Part 311: Performance requirements and test circuits for gas discharge tubes (GDT)*

IEC 61643-321, *Components for low-voltage surge protective devices – Part 321: Specifications for avalanche breakdown diode (ABD)*

IEC 61643-331, *Components for low-voltage surge protection – Part 331: Performance requirements and test methods for metal oxide varistors (MOV)*

IEC 61800 (all parts), *Adjustable speed electrical power drive systems*

IEC 62133 (all parts), *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

IEC 62366, *Medical devices – Application of usability engineering to medical devices*

IEC 62368 (all parts), *Audio/video, information and communication technology equipment*

ISO 9241, (all parts), *Ergonomics of human-system interaction*

ISO 13732-1, *Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces – Part 1: Hot surfaces*

ISO 13854, *Safety of machinery – Minimum gaps to avoid crushing of parts of the human body*

ISO 14121-1, *Safety of machinery – Risk assessment – Part 1: Principles*

ISO 14738, *Safety of machinery – Anthropometric requirements for the design of workstations at machinery*

ISO 14971, *Medical devices – Application of risk management to medical devices*

ISO/IEC Guide 117, *Electrotechnical equipment – Temperatures of touchable hot surfaces*

ANSI B11.TR3, *Risk Assessment and Risk Reduction – A Guide to Estimate, Evaluate and Reduce Risks Associated with Machine Tools*

ANSI/UL 94, *Standard for safety of flammability of plastic materials for parts in devices and appliances testing*

ANSI/UL 248-14, *Low-Voltage Fuses – Part 14: Supplemental Fuses*

ANSI/UL 471, *Standard for Commercial Refrigerators and Freezers*

ANSI/UL 746E, *Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards*

ANSI/UL 2556, *Wire and Cable Test Methods*

EN 349, *Safety of machinery. Minimum gaps to avoid crushing of parts of the human body*

EN 894-2, *Safety of machinery. Ergonomics requirements for the design of displays and control actuators. Displays*

EN 894-3, *Safety of machinery. Ergonomics requirements for the design of displays and control actuators. Control actuators*

SEMI S8, *Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment*

SEMI S10, *Safety guideline for risk assessment*

UL 1439, *Standard for Tests for Sharpness of Edges on Equipment*

UL 508:2018, *Standard for Industrial Control Equipment*

UL 1059, *Standard for Terminal Blocks*

UL 1642, *Standard for Lithium Batteries*

UL 2054, *Standard for Household and Commercial Batteries*

Pressure Equipment Directive (2014/68/EU)

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IEC 61010-2-201

Edition 3.0 2024-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Safety requirements for electrical equipment for measurement, control, and laboratory use –
Part 2-201: Particular requirements for control equipment

Exigences de securité pour appareils électriques de mesurage, de régulation et de laboratoire –
Partie 2-201: Exigences particulières pour les équipements de commande

IEC 61010-2-201:2024-10(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 2-201: Particular requirements for control equipment

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 61010-2-201 has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2017. This edition constitutes a technical revision.

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

a) 1.1.1: the related equipment included in the Scope has been clarified;
b) 4.3.2.101: the optical fibre module has been deleted;
c) 5.4.3: equipment installation has been clarified;

d) 6.7.1.1: revision of the figure representing insulation between separate circuits has been included;
e) 6.7.101: the subclause relating to insulation for FIELD WIRING TERMINALS of OVERVOLTAGE CATEGORY II with a nominal voltage up to 1 000 V has been deleted;
f) 6.7.1.101: a new subclause relating to insulation for SELV/PELV CIRCUITS has been included;
g) 6.8.3: specification of voltage tester has been added;
h) 6.9.3: an additional exception relating to colour coding has been included;
i) 6.9.101: a new subclause relating to wiring for secondary circuits e.g. SELV/PELV has been included;
j) 8.2.2.101: additional requirements for glass displays have been included;
k) 8.3: the subclause relating to the drop test has been removed;
l) 9.3.2: additional requirements for material of connectors and insulating material have been included;
m) The particular requirements for non-metallic material have been clarified;
n) Clause 11: the particular requirements for protection against HAZARDS from fluid and solid foreign objects have been removed;
o) 12.4: an additional subclause relating to microwave radiation has been included;
p) 14.102: the description of switching devices has been clarified;

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

Draft	Report on voting
65/1049/FDIS	65/1095/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/standardsdev/publications.

A list of all parts in the IEC 61010 series, published under the general title *Safety requirements for electrical equipment for measurement, control, and laboratory use*, can be found on the IEC website.

This document is to be used in conjunction with IEC 61010-1:2010, and IEC 61010-1:2010/AMD1:2016.

This document supplements or modifies the corresponding clauses in IEC 61010-1 so as to convert that publication into the IEC standard: *Particular requirements for control equipment.*

Where a particular subclause of IEC 61010-1 is not mentioned in this document, that subclause applies as far as is reasonable. Where this document states "addition", "modification", "replacement", or "deletion", the relevant requirement, test specification or note in IEC 61010-1 should be adapted accordingly.

In this document,

a) the following print types are used:
   – requirements and definitions: in roman type;
   – NOTES: in smaller roman type;
   – *conformity and tests: in italic type*;
   – terms used throughout this document which have been defined in Clause 3: SMALL ROMAN CAPITALS.
b) subclauses, figures, tables and notes which are additional to those in IEC 61010-1 are numbered starting from 101. Additional annexes are lettered starting from AA and additional list items are lettered from aa).

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,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 61010-2-2xx documents are a series of standards on the safety of industrial-process measurement, control and automation equipment.

This document specifies the complete safety related requirements and related tests for control equipment (e.g. programmable controller (PLC), the components of distributed control systems (DCS), I/O devices, human machine interface (HMI)).

Safety terms of general use are defined in IEC 61010-1. More specific terms are defined in each relevant part of the IEC 61010 series.

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

Part 2-201: Particular requirements for control equipment

1 Scope and object

IEC 61010-1:2010, Clause 1 and IEC 61010-1:2010/AMD1:2016, Clause 1 apply, except as follows:

1.1.1 Equipment included in scope

Replacement:

Replace the existing text with the following:

This part of IEC 61010 specifies safety requirements and related verification tests for control equipment or their associated peripherals, or both.

Some equipment examples are:

- programmable logic controller (PLC);
- programmable automation controller (PAC);
- distributed control systems (DCS);
- industrial PC (computers) and panel PC;
- programming and debugging tools (PADTs);
- displays and human-machine interfaces (HMI);
- any product performing the function of control equipment or their associated peripherals, or both;
- positioners; and
- control equipment which have as their intended use the command and control of machines, automated manufacturing and industrial processes, for example discrete and continuous control.

Components of the above named equipment and within the scope of this document are, for example:

- (auxiliary) stand-alone power supplies;
- peripherals such as digital and analogue I/O,
- remote-I/O;
- industrial network equipment, embedded or stand-alone (e.g. switches, routers, wireless base station).

Control equipment and their associated peripherals are intended to be used in an industrial environment. This document considers equipment designed as OPEN or ENCLOSED EQUIPMENT.

NOTE 1 Control equipment intended also for use in other environments or for other purposes (example: for use in building installations to control light or other electrical installations, or for use on cars, trains or ships) can have additional conformity requirements defined by the safety standard(s) for these applications. These requirements can involve for example: insulation, spacings and power restrictions.

NOTE 2 Computing devices and similar equipment within the scope of the IEC 60950 series or the IEC 62368 series and conforming to their requirements are considered to be suitable for use with control equipment within the scope of this document. However, some of the requirements of the IEC 60950 series for resistance to moisture and liquids are less stringent, IEC 61010-1:2010, 5.4.4, second paragraph takes this aspect into account.

Control equipment covered in this document is typically intended for use in OVERVOLTAGE CATEGORY II (IEC 60664-1) in low-voltage installations, where the RATED equipment supply voltage does not exceed 1 000 V a.c. RMS (50/60 Hz), or 1 000 V d.c..

Where control equipment is intended for installation to supply systems with OVERVOLTAGE CATEGORY III or IV, additional requirements are identified in Annex K.

The requirements of ISO/IEC Guide 51 and IEC Guide 104, as they relate to this part of IEC 61010, are incorporated herein.

1.1.2 Equipment excluded from scope

Replacement:

Replace the existing text with the following:

This document does not deal with aspects of the overall automated system, for example a complete assembly line. Control equipment (e.g. DCS and PLC), their application programme and their associated peripherals are considered as components (components in this context are items which perform no useful function by themselves) of an overall automated system.

Since control equipment (e.g. DCS and PLC) are component devices, safety considerations for the overall automated system including installation and application are beyond the scope of this document. Refer to the IEC 60364 series or applicable national and local regulations for electrical installation and guidelines.

1.2.1 Aspects included in scope

Replace the first sentence with the following:

The purpose of the requirements of this document is to ensure that all HAZARDS to the OPERATOR, SERVICE PERSONNEL and the surrounding area are reduced to a tolerable level.

NOTE By using the terms "OPERATOR" and "SERVICE PERSONNEL" this document considers the perception of HAZARDS depending on training and skills. Annex AA provides a general approach in this regard.

1.2.2 Aspects excluded from scope

Replacement:

Replace the existing text with the following:

This document does not cover:

a) reliability, functionality, performance, or other properties of the control equipment not related to safety;
b) mechanical or climatic requirements for operation, transport or storage;
c) EMC requirements (see e.g. the IEC 61326 series or IEC 61131-2);
d) protective measures for explosive atmospheres (see e.g. the IEC 60079 series);
e) functional safety (see e.g. the IEC 61508 series, IEC 61131-6).

2 Normative references

IEC 61010-1:2010, Clause 2 and IEC 61010-1:2010/AMD1:2016, Clause 2 apply, except as follows:

Addition:

Add the following new references:

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

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end products (GWEPT)*

IEC 60695-11-3, *Fire hazard testing – Part 11-3: Test flames – 500 W flames – Apparatus and confirmational test methods*

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

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – Semiconductor motor controllers, starters and soft-starters*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

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 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61810-1:2015, *Electromechanical elementary relays – Part 1: General and safety requirements*

3 Terms and definitions

IEC 61010-1:2010, Clause 3 applies, except as follows:

3.1.3
PORTABLE EQUIPMENT

Modification:

Replace the definition with the following:

equipment intended to be carried by hand and not fixed during NORMAL USE

3.2.3
PROTECTIVE CONDUCTOR TERMINAL

Modification:

Replace the term "PROTECTIVE CONDUCTOR TERMINAL" *with* "PROTECTIVE EARTH TERMINAL" *and add the following Note to entry:*

Note 1 to entry: PROTECTIVE EARTH TERMINAL is most familiar to industrial users, manufacturers, etc. Therefore since this document is targeted towards industrial use, the most familiar term is utilized.

3.2.4
ENCLOSURE

Replacement:

Replace the definition and NOTE with the following:

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

[SOURCE: IEC 60050-151:2001, 151-13-08]

Add the following new terms and definitions:

3.101
AMBIENT TEMPERATURE
temperature, determined under specified conditions, of the air surrounding the equipment

3.102
ENCLOSED EQUIPMENT
equipment which includes an ENCLOSURE, having safety capability, or a combination of an ENCLOSURE, having safety capability, and installation provisions enclosing on all sides, with the possible exception of its mounting surface, to prevent personnel from accidentally touching HAZARDOUS LIVE, hot or moving parts contained therein and meeting requirements of mechanical strength, flammability, and stability (where applicable)

EXAMPLE HAND-HELD EQUIPMENT.

Note 1 to entry: This definition is related to IEC 60050-441:1984, 441-12-02.

3.103
FIELD WIRING
wiring of the control equipment, which is not installed in the control equipment manufacturer's facility

EXAMPLE MAINS supply wiring.

3.104
INTERFACE
shared boundary between one control equipment and another control equipment, or between parts of a control equipment, through which information or electrical energy is conveyed

[SOURCE: IEC 61131-2:2017, 3.1.21]

3.105
MODULAR EQUIPMENT
equipment consisting of different modules such as a Rack, CPU, different I/O-modules, network modules

Note 1 to entry: MODULAR EQUIPMENT can:

a) be OPEN EQUIPMENT or ENCLOSED EQUIPMENT;

b) consist of modules that cannot operate alone or of a basic module that is operational alone and can be enhanced in function by additional modules;

c) vary in size and functionality depending on the combination and the number of modules;

d) be combined with operational equipment or enhanced in function by the addition of modules by the customer.

3.106
OPEN EQUIPMENT
equipment which does not protect personnel from accidentally touching HAZARDOUS LIVE or moving parts contained therein nor meet requirements of mechanical strength, flammability and stability (where applicable)

Note 1 to entry: See Annex AA.

3.107
PANEL MOUNTED EQUIPMENT
equipment where a portion of the equipment may form part of the ENCLOSURE

Note 1 to entry: See Figure 103.

3.108
PORT
access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: PORT is most commonly used with respect to EMC.

3.109
PROTECTIVE EXTRA-LOW VOLTAGE CIRCUIT
PELV CIRCUIT
protective earth referenced electrical circuit in which the voltage cannot exceed the following:

NORMAL CONDITION and SINGLE FAULT CONDITION: The a.c. voltage levels are 30 V RMS, 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V RMS, 22,6 V peak and the d.c. voltage level is 35 V

Note 1 to entry: Transients are not taken into consideration in PELV CIRCUITS.

[SOURCE: IEC 60050-195:2021, 195-06-29, modified – In the preferred term, "system" has been replaced with "circuit", a full description and clarifications have been added and the Note to entry has been replaced with a new Note to entry.]

3.110
SAFETY EXTRA-LOW VOLTAGE CIRCUIT
SELV CIRCUIT
non-protective earth referenced electrical circuit in which the voltage cannot exceed the following:

NORMAL CONDITION and SINGLE FAULT CONDITION: The a.c. voltage levels are 30 V RMS, 42,4 V peak and the d.c. voltage level is 60 V. For equipment intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V RMS, 22,6 V peak and the d.c. voltage level is 35 V

Note 1 to entry: Transients are not taken into consideration in SELV CIRCUITS.

[SOURCE: IEC 60050-195:2021, 195-06-28, modified – In the preferred term, "system" has been replaced with "circuit", a full description and clarifications have been added and the Note to entry has been replaced with a new Note to entry.]

3.111
SERVICE PERSONNEL
person who is installing, changing or repairing the control equipment, with the appropriate technical training, experience and awareness of HAZARDS and of measures to minimize danger to themselves, other persons or to the control equipment, in an industrial environment

Note 1 to entry: SERVICE PERSONNEL are persons having the appropriate technical training and experience necessary to be aware of HAZARDS – e.g. electrical HAZARDS, temperature HAZARDS, fire HAZARDS – to which they are exposed in performing a task and of measures to minimize danger to themselves or to other persons or to the control equipment, in an industrial environment.

Note 2 to entry: SERVICE PERSONNEL change or repair control equipment e.g. hardware configuration or installation of software updates provided by the manufacturer.

Note 3 to entry: See AA.1.3 for more detail.

4 Tests

IEC 61010-1:2010, Clause 4 and IEC 61010-1:2010/AMD1:2016, Clause 4 apply, except as follows:

4.1 General

Add the following three paragraphs of requirements after the third paragraph of requirements, before the first conformity statement:

The product is verified in accordance with this document in a documented test configuration, which represents the least favourable configuration. See 4.3.

It is likely or possible that there are different test configurations which yield least favourable test conditions. For example there can be a least favourable configuration for the temperature test, and a different least favourable test configuration for the voltage test. If this is the case then the appropriate least favourable test configuration(s) shall be used with regard to 4.3.2 and 4.4.

These least favourable test configurations and test conditions shall be practical and useful for the intended applications.

Add the following conformity statement at the end of the list of conformity statements:

Conformity verification: The selected test configuration(s) and test conditions shall be documented with the rationale in the test report.

4.4.1 General

Add the following note to item a):

NOTE A fault condition can include open or short circuit of components, as well as disabling or bridging one means or layer of protection.

4.4.4.3 Spread of fire

Add the following to the conformity statement:

Optionally, for OPEN EQUIPMENT*:*

The equipment may be placed inside a wire mesh cage covered with cheesecloth. The wire mesh cage shall be maximum 1,5 times the size (length, width, height) of the device or representative system including the device, to simulate the intended ENCLOSURE *during the single fault condition testing. See 10.4.1.101 for representative system methodology.with a tolerance of*

The wire mesh cage shall be a metal screen with a mesh 25 mm × 25 mm with a tolerance of 5 mm, centre to centre with a wire diameter of 0,8 mm ± 0,3 mm.

NOTE 1 The wire mesh used is commonly known as chicken wire, 25 mm hexagonal mesh weave made of 0,81 gauge wire.

Cheesecloth is a bleached cotton cloth of approximately 40 g/m^2 containing no flame retardants.

NOTE 2 Cheesecloth is a coarse, loosely woven cotton gauze, originally used for wrapping cheese.

NOTE 3 Panel mounted equipment can combine the two methods.

5 Marking and documentation

IEC 61010-1:2010, Clause 5 and IEC 61010-1:2010/AMD1:2016, Clause 5 apply, except as follows:

5.1.3 MAINS supply

Replace line 14 of Table 1 with the following:

14		ISO 7000-0434A: 2004-01 or ISO 7000-0434B: 2004-01	Caution

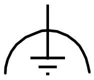
IEC

5.1.5.2 TERMINALS

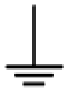
Modification:

Replace item a) as follows:

a) FUNCTIONAL EARTH TERMINALS (i.e. used for non-safety purposes such as interference immunity improvement) shall be marked with one of the following symbols:



IEC 60417-5018 (2011-07) or



IEC 61010-1:2010, symbol 5 of Table 1, IEC 60417-5017 (2006-08).

Where a TERMINAL serves both as the PROTECTIVE CONDUCTOR TERMINAL and as a FUNCTIONAL EARTH TERMINAL, symbol 6 of Table 1 and other requirements for PROTECTIVE CONDUCTOR TERMINAL shall be applied. Where a TERMINAL serves both as an earth (ground) TERMINAL and FUNCTIONAL EARTH TERMINAL, symbol 5 of Table 1 and other requirements for earth TERMINALS shall be applied.

Addition:

Add the following new item after d):

aa) If a TERMINAL has a hazardous voltage level, the TERMINAL shall be marked with symbol 14 of Table 1.

5.1.8 FIELD WIRING TERMINAL boxes

Addition:

Add the following new text after the first paragraph:

A FIELD WIRING TERMINAL need not be marked to indicate the temperature RATING if it is intended for the connection of a control circuit conductor only.

A control circuit is any circuit that does not carry MAINS power and is generally limited to 15 A.

5.4.1 General

Addition:

Add the following new text:

For equipment intended to be installed by SERVICE PERSONNEL or trained installers, all documentation may be provided by electronic media.

Where the documentation is provided by electronic media, this may be accomplished by including symbol 14 of Table 1, on the product, and the location of the documentation, for example URL, QRcode, on the product, packaging or printed information with the product.

Annex EE provides details on the flow of information, regarding safety aspects, for controls and its accessory in an industrial use.

5.4.2 Equipment RATINGS

Addition:

Add the following new items:

aa) *digital input devices shall be rated in volts and shall also indicate whether the input device is intended for direct or alternating current;*

bb) *analogue input and analogue output devices shall be rated in the voltage range or current range, or both, as applicable;*

cc) *digital and switching output devices shall be rated in voltage and one or more of the following depending on intended load type:*

1) *general purpose: amperes;*
2) *coil: code designation, volt-amperes, amperes and inrush amperes; or amperes and the words "pilot duty";*
3) *resistance: amperes, resistance, only;*
4) *resistive heating: amperes, resistive heating;*
5) *incandescent lamp: amperes or watts, tungsten;*
6) *ballast (electric discharge lamp): amperes, ballast;*
7) *ballast, electronic (electric discharge lamp): amperes, electronic fluorescent ballast;*
8) *motor: horsepower or full-load current and locked-rotor current;*
9) *a device intended for control of a specific load type not addressed above shall be marked to indicate the specific load type in standard terminology;*

dd) *a device which is intended for use with a specific model load (e.g. specific motor or coil) or input sourcing device (e.g. specific transducer or power supply) shall be documented with the manufacturer's name and model number of the device with which it is intended to be used.*

5.4.3 Equipment installation

Addition:

Add the following new item:

aa) OPEN EQUIPMENT: If the control equipment is evaluated in accordance with 9.1.c) and 9.3.2 for hazards related to the spread of fire (containment of fire within the equipment, if it occurs), it can be necessary for the installation documentation to specify necessary constructional requirements applicable for the end use location, for example acceptable ventilation openings, as applicable.

NOTE 101 See also 7.1.101, 8.1.101 and 9.3.2.

NOTE 102 Subclause 9.1 states that it is possible for different circuits or parts of the equipment to be evaluated to different methods (9.1 a), b) or c)).

Modification:

Replace item d)1) with the following:

d) 1) supply and FIELD WIRING requirements, for example insulation, temperature RATING;

5.4.4 Equipment operation

Modification:

Replace item j) with the following:

j) details of methods of reducing the RISKS of burns from surfaces permitted to exceed the temperature limits of 10.1, Table 19.

6 Protection against electric shock

IEC 61010-1:2010, Clause 6 and IEC 61010-1:2010/AMD1:2016, Clause 6 apply, except as follows:

6.1.2 Exceptions

Replacement:

Replace the text with the following:

If it is not feasible for operating reasons to prevent the following parts being both ACCESSIBLE and HAZARDOUS LIVE, they are permitted to be ACCESSIBLE to SERVICE PERSONNEL during NORMAL USE while they are HAZARDOUS LIVE:

For example:

a) parts of lamps and lamp sockets after lamp removal;

b) parts intended to be replaced by SERVICE PERSONNEL (e.g. batteries) and which can be HAZARDOUS LIVE during the replacement or other SERVICE PERSONNEL action, but only if they are ACCESSIBLE only by means of a TOOL and have a warning marking (see 5.2).

If any of the parts in examples a) and b) receive a charge from an internal capacitor, they shall not be HAZARDOUS LIVE 10 s after interruption of the supply.

If a charge is received from an internal capacitor, conformity is checked by the measurements of 6.3 to establish that the levels of 6.3.1 c) are not exceeded.

6.2.1 General

IEC 61010-1:2010, Subclause 6.2.1 and IEC 61010-1:2010/AMD1:2016, Subclause 6.2.1 are applicable to ENCLOSED EQUIPMENT.

6.2.2 Examination

IEC 61010-1:2010, Subclause 6.2.2 is applicable to ENCLOSED EQUIPMENT.

6.2.3 Openings above parts that are HAZARDOUS LIVE

IEC 61010-1:2010, Subclause 6.2.3 is applicable to ENCLOSED EQUIPMENT.

6.2.4 Openings for pre-set controls

Addition:

Add the following paragraph as a new first paragraph:

IEC 61010-1:2010, Subclause 6.2.4 is applicable to ENCLOSED EQUIPMENT. This subclause applies to SERVICE PERSONNEL only.

Addition:

Add the following subclauses:

6.2.101 Accessibility of INTERFACES, PORTS and TERMINALS

INTERFACES, PORTS and TERMINALS, as listed in Table 101, shall be prevented from becoming both OPERATOR ACCESSIBLE and HAZARDOUS LIVE under normal and single-fault conditions.

Other than for Ports Ar, Be and E, protection can generally be achieved by making the HAZARDOUS LIVE parts, of the INTERFACE, PORT or TERMINAL, not ACCESSIBLE.

See also Figure 101.

Table 101 – INTERFACES, PORTS AND TERMINALS considered as OPERATOR ACCESSIBLE for OPEN and ENCLOSED EQUIPMENT

	INTERFACES, PORTS and TERMINALS	Considered as OPERATOR ACCESSIBLE: OPEN EQUIPMENT[c]	Considered as OPERATOR ACCESSIBLE: ENCLOSED EQUIPMENT[d]
Al	communication INTERFACE/PORT for local extension rack	No	Yes
Ar	communication INTERFACE/PORT for remote devices (e.g. IO station, control network, fieldbus)[a]	Yes	Yes
Be	open communication INTERFACE/PORT, also open to third-party devices (e.g. PADT, personal computer used for programming)[a]	Yes	Yes
Bi	internal communication INTERFACE/PORT for peripherals	No	Not applicable[b]
C	INTERFACE/PORT for digital and analogue input signals	No	Yes
D	INTERFACE/PORT for digital and analogue output signals	No	Yes
E	serial or parallel communication INTERFACES/PORTS for data communication with third-party devices (e.g. computers and printers)[a]	Yes	Yes
F	equipment power input INTERFACE/PORT	No	Yes
G	PROTECTIVE EARTH TERMINAL	No	Yes
H	FUNCTIONAL EARTH TERMINAL/PORT	No	Yes
J	I/O power input INTERFACE/PORT	No	Yes
K	auxiliary power output INTERFACE/PORT for external devices (e.g. to supply sensors, actuators, HMI)	No	Yes

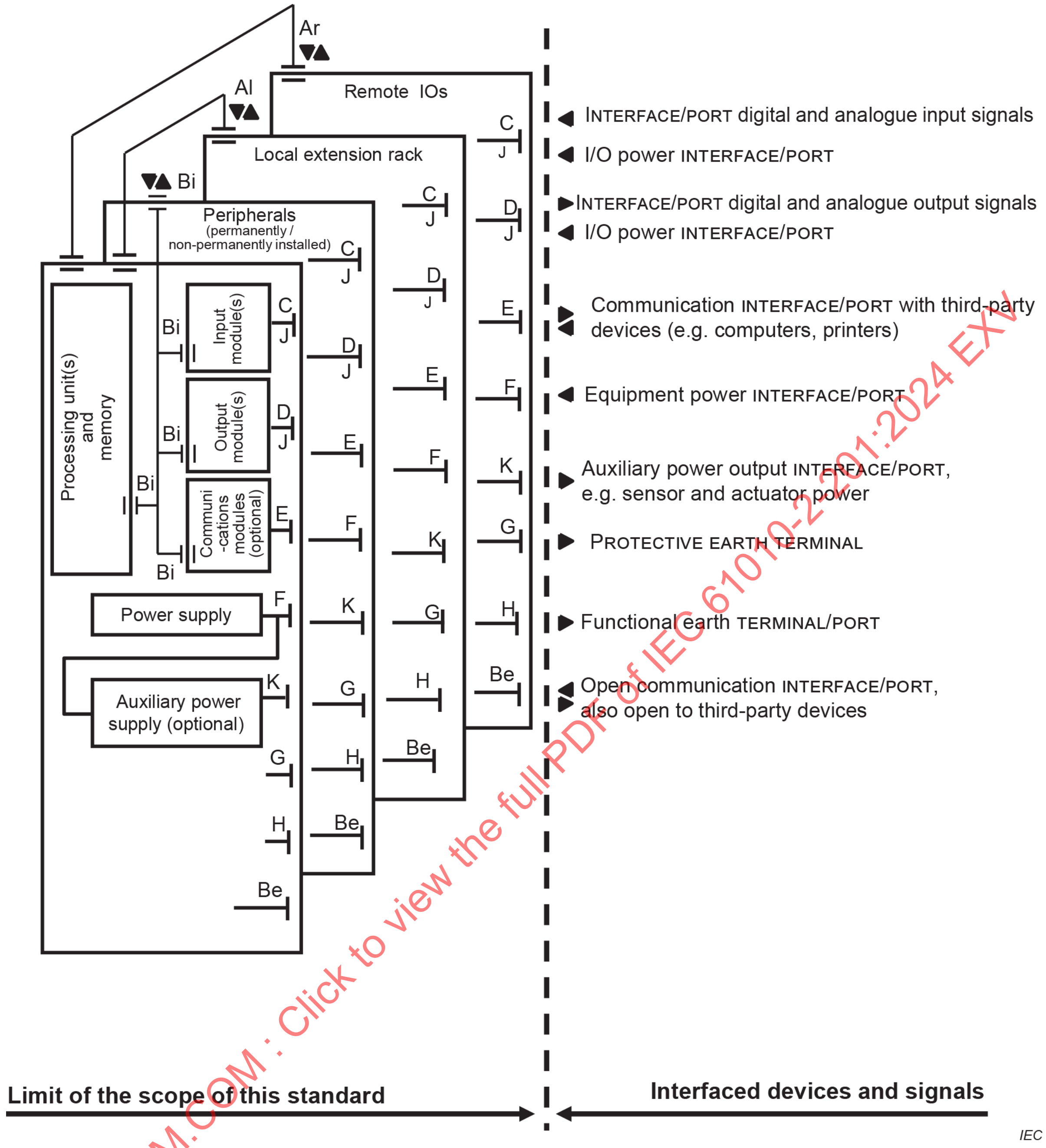
NOTE INTERFACE/PORT/TERMINAL designation as used in this table, is aligned with the IEC 61131 series.

[a] Ports Ar, Be and E contain circuits which may be connected to other equipment, where the remote side of the connecting cable can be ACCESSIBLE, and require therefore to be considered for OPEN EQUIPMENT.

[b] Port Bi is an internal communication port and thus never leaves the ENCLOSED EQUIPMENT, by definition.

[c] Depending on the intended use of the connected equipment, INTERFACES/PORTS of OPEN EQUIPMENT shall be considered OPERATOR ACCESSIBLE, when the remote side of the connecting cable or circuit can be ACCESSIBLE.

[d] Depending on the intended use of the connected equipment, INTERFACES/PORTS of ENCLOSED EQUIPMENT may be considered as not OPERATOR ACCESSIBLE, where the construction of the INTERFACE/PORT and the remote side of the connecting cable or circuit are not ACCESSIBLE.



Key

Al	Communication INTERFACE/PORT for local extension rack
Ar	Communication INTERFACE/PORT for remote I/O station, control network, fieldbus
Be	Open communication INTERFACE/PORT, open to third-party devices, e.g. PADT, personal computer used for programming
Bi	Internal communication INTERFACE/PORT, e.g. backplane bus
C	Interface/port for digital and analog input signals
D	Interface/port for digital and analog output signals
E	Serial or parallel communication INTERFACES/PORTS for data communication with third-party devices, e.g. computers, printers
F	Equipment power INTERFACE/PORT
G	PROTECTIVE EARTH TERMINAL/PORT
H	FUNCTIONAL EARTH TERMINAL/PORT
J	I/O power INTERFACE/PORT
K	Auxiliary power output INTERFACE/PORT, e.g. sensor and actuators power

Figure 101 – Typical INTERFACE/PORT of control equipment

Conformity is checked by inspection and in case of doubt by measurement and test in accordance with 6.2 and 6.3.

6.2.102 Control equipment

6.2.102.1 ACCESSIBLE parts

ACCESSIBLE parts of control equipment shall not be, or in the case of a single fault become, HAZARDOUS LIVE. Although these requirements are principally directed at ENCLOSED EQUIPMENT, these requirements also apply to OPEN EQUIPMENT. When applied to OPEN EQUIPMENT, the control equipment shall be considered to be installed in accordance with the installation instructions. Also see 5.4.3 and Annex AA.

If SERVICE PERSONNEL are required to make adjustments, etc., for example during the commissioning of OPEN EQUIPMENT, then protection from HAZARDS in the area near the adjustment shall be provided to prevent contact. If the HAZARD is not indicated by a warning label (see 5.2) then other protective means, for example ENCLOSURE or PROTECTIVE BARRIER is required.

Conformity is checked by inspection and examination in accordance with 6.2.2.

6.2.102.2 SELV/PELV CIRCUITS

SELV/PELV CIRCUITS do not require additional evaluation for RISK against electrical shock, provided that those circuits are in dry locations.

6.5.1 General

Addition:

Add the following subclauses:

6.5.1.101 Classes of equipment or equipment classes

6.5.1.101.1 General

Equipment classes are described to designate the means by which electric shock protection is maintained in NORMAL CONDITION and SINGLE-FAULT CONDITIONS of the equipment.

NOTE Derived from IEC 61140:2016, Clause 7.

6.5.1.101.2 Class I equipment

Class I equipment is equipment in which protection against electric shock is achieved using BASIC INSULATION, and additionally connecting accessible conductive parts to the protective earth conductor.

Class I equipment can have parts with DOUBLE INSULATION or REINFORCED INSULATION or parts operating at safety extra-low voltage.

If a flexible cord is utilized, it shall include a provision for a protective earth conductor that shall be part of the cord set.

ACCESSIBLE conductive parts of equipment, which can become HAZARDOUS LIVE in the event of a single fault, shall be connected to the protective circuit of the equipment. Conductive parts, such as screws, rivets and nameplates, which otherwise could become HAZARDOUS LIVE under single-fault conditions, shall be protected by other means such as DOUBLE/REINFORCED INSULATION so that they do not become HAZARDOUS LIVE.

When a part of the equipment is removed from the ENCLOSURE, for normal maintenance, for example, the protective circuits serving other parts of the equipment shall not be interrupted.

Protective earth requirements are specified in 6.5.2.102 or 6.5.2.103.

6.5.1.101.3 Class II equipment

Class II equipment is equipment in which protection against electric shock does not rely on BASIC INSULATION only, but also on the provision of additional safety precautions, such as DOUBLE INSULATION or REINFORCED INSULATION. There is no provision for protective earth or reliance upon installation conditions.

A PROTECTIVE IMPEDANCE may be used in lieu of DOUBLE or REINFORCED INSULATION.

A means for maintaining the continuity of circuits is acceptable provided that these circuits are double insulated from the ACCESSIBLE circuits of the equipment.

Connection to the earth TERMINALS for functional purposes is acceptable (such as radiofrequency interference suppression) provided the DOUBLE or REINFORCED INSULATION system is still provided for protective purposes.

Equipment shall be of one of the following types:

a) insulation-encased by a durable and substantially continuous ENCLOSURE of insulating material which envelops all conductive parts. Small parts, such as nameplates, screws and rivets are exempted if they are isolated from HAZARDOUS LIVE parts by insulation at least equivalent to REINFORCED INSULATION;
b) metal-encased by a substantially continuous metal ENCLOSURE, in which DOUBLE INSULATION is used throughout, except for those parts where REINFORCED INSULATION is used;
c) combination of a) and b).

NOTE 1 Insulation-encasement can form a part of the whole of the SUPPLEMENTARY INSULATION or of the REINFORCED INSULATION.

NOTE 2 Utilization of DOUBLE INSULATION or REINFORCED INSULATION, or both, throughout, with a PROTECTIVE EARTH TERMINAL or contact, is deemed to be of Class I construction.

NOTE 3 This equipment can have parts operating at safety extra-low voltage.

6.5.1.101.4 Class III equipment

Class III equipment is equipment in which protection against electric shock is provided by circuits supplied by safety extra-low voltage (SELV/PELV). And additionally, the voltages generated by or within the equipment do not exceed the limits for SELV/PELV.

Connection to the earth TERMINALS for functional purposes is acceptable (such as radiofrequency interference suppression).

6.5.2.1 General

Addition:

Add the following note at the end of the first paragraph:

NOTE PROTECTIVE EARTH TERMINALS and earth contacts are not connected directly to the neutral TERMINAL within the equipment. This does not prevent the connection of appropriately RATED devices (such as capacitors or surge suppression devices) between the PROTECTIVE EARTH TERMINAL and neutral.

6.5.2.2 Integrity of PROTECTIVE BONDING

Addition:

At the end of item h) add the following note:

NOTE 1 In some countries green colour can be utilized instead of green-and-yellow.

Add the following new item:

aa) PROTECTIVE BONDING shall not rely on a communication network.

NOTE 2 A communication network, in this context, is a metallically terminated transmission medium intended for communication between equipment that can be located in separate buildings, excluding: the MAINS system for supply, transmission and distribution of electrical power, if used as a communication transmission medium.

6.5.2.6 Transformer PROTECTIVE BONDING screen

Modification:

Add the following second paragraph:

If the control equipment has no overcurrent protection means for the winding then the test current shall be twice the RATING of the control equipment overcurrent protection means (e.g. fuse, circuit breaker). This overcurrent protection means may either be integrated into the control equipment or specified in the manual.

Add the following subclauses:

6.5.2.101 Protective earth requirements for ENCLOSED EQUIPMENT

The ACCESSIBLE parts of Class I equipment (e.g. chassis, frame and fixed metal parts of metal ENCLOSURES) other than those which cannot become HAZARDOUS LIVE shall be electrically interconnected and connected to a PROTECTIVE EARTH TERMINAL.

This requirement can be met by structural parts providing adequate electrical continuity. This applies whether the equipment is used on its own or incorporated in an assembly.

Cords or cables that supply power to Class I equipment PORTABLE EQUIPMENT peripherals shall be provided with a protective earth conductor.

ACCESSIBLE isolated conductive parts are considered not to constitute a danger if they are so located as to exclude any contact with live parts and withstand the dielectric test voltage of Table 5 for REINFORCED INSULATION, corresponding to the highest RATED operational voltage of the unit.

Class II equipment may have an internal functional earth bonding conductor but shall not be provided with a PROTECTIVE EARTH TERMINAL or a protective earth conductor in the equipment power input cord.

If the equipment is provided with a PROTECTIVE EARTH TERMINAL (Class I equipment), the following requirements also apply in addition to the previous general connection specifications.

- The PROTECTIVE EARTH TERMINAL shall be readily ACCESSIBLE and so placed that the connection of the equipment to the protective earth conductor is maintained when the cover or any removable part is removed.
- Products which are intended for MAINS cord connected use (such as equipment peripherals) shall be provided with a PROTECTIVE EARTH TERMINAL integral to the plug cap or socket (if removable cord set).

- The PROTECTIVE EARTH TERMINAL shall be of screw, stud or pressure type and shall be made of a suitable corrosion resistant material.
- The clamping means of PROTECTIVE EARTH TERMINALS shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a TOOL.
- PROTECTIVE EARTH TERMINALS and earth contacts shall not be connected direct to the neutral TERMINAL within the equipment. This does not prevent the connection of appropriately RATED devices (such as capacitors or surge suppression devices) between the PROTECTIVE EARTH TERMINAL and neutral.
- The PROTECTIVE EARTH TERMINAL and subsequent protective equipment internal to the equipment shall comply with the requirements in 6.5.2.4 or 6.5.2.5.
- The PROTECTIVE EARTH TERMINAL shall have no other function.

6.5.2.102 Protective earth requirements for OPEN EQUIPMENT

OPEN EQUIPMENT shall comply with the requirements of 6.5.2.4 or 6.5.2.5 with the exception that the provision for connection to an external protective conductor may be replaced by a means for bonding to the ENCLOSURE ACCESSIBLE to the OPERATOR.

6.6.1 General

Modification:

Replace NOTE 2 as follows:

NOTE 2 For cord connected MAINS supply, see 6.10.

6.6.2 TERMINALS for external circuits

Modification:

Add at the beginning of the subclause:

An external circuit is a circuit connected by FIELD WIRING of the control equipment.

All parts of TERMINALS that maintain contact and carry current shall be of metal of adequate mechanical strength.

The mechanical design of the interfaces shall allow that no individual conductor is subjected to bending of a radius of curvature less than six times its diameter after removal of the covering elements (armour, sheaths, fillers).

Conformity is checked by inspection.

6.6.3 Circuits with TERMINALS which are HAZARDOUS LIVE

Replacement:

Replace the existing text with the following:

This subclause applies to both TERMINALS and PORTS (see Table 101).

For ENCLOSED EQUIPMENT no ACCESSIBLE conductive parts may be HAZARDOUS LIVE. For OPEN EQUIPMENT protection for those TERMINALS and PORTS defined in Table 101 shall be provided.

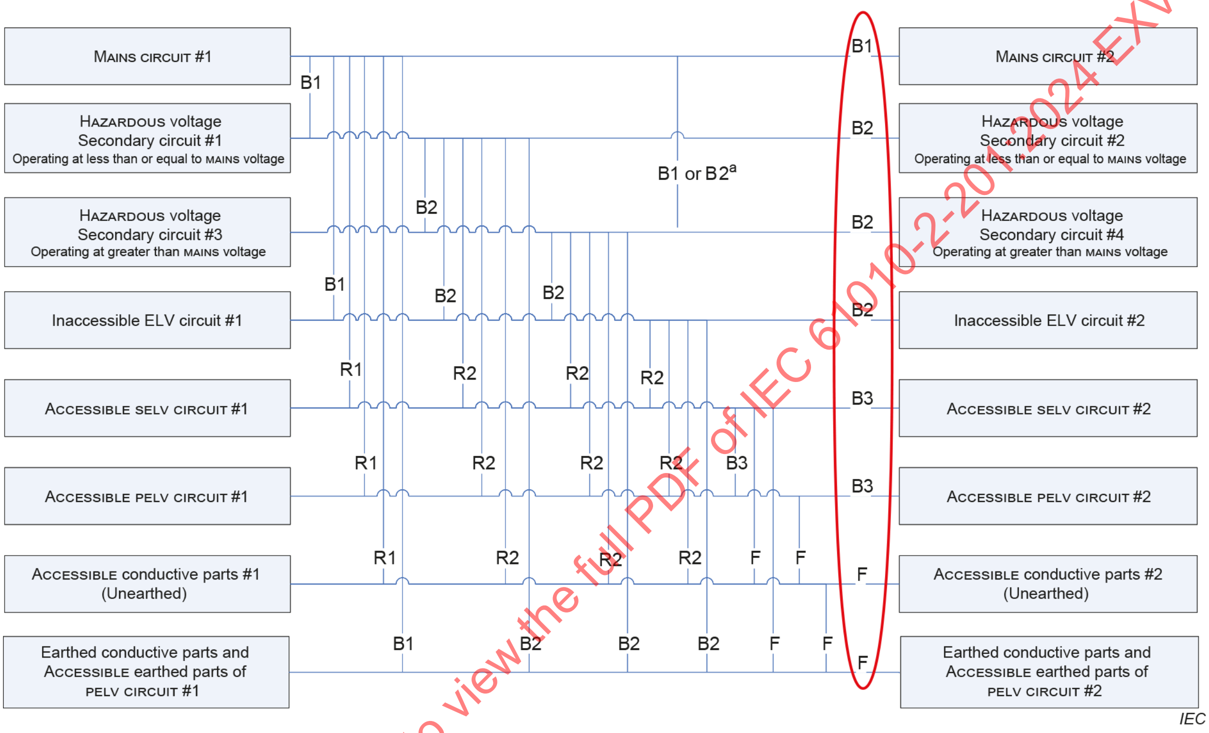
Conformity is checked by inspection.

6.7.1.1 General

Modification:

Add after the first paragraph:

Insulation between separate circuits and between circuits and ACCESSIBLE conductive parts are shown in Figure 102. Figure 102 does not encompass all possibilities, rather it depicts a set of common situations. Further information, particularly in the context of OPEN EQUIPMENT, is given in Annex BB.



a Where both B1 and B2 may apply, the greater requirement shall be applied across the separation.

B1 Separation between circuits shall provide minimum one level of protection, as required in 6.4. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.2, Clause K.1 or Clause K.3.

B2 Separation between circuits shall provide minimum one level of protection, as required in 6.4. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.3, Clause K.2 or Clause K.3.

B3 Separation between circuits shall provide minimum one level of protection. Where distances are required, CREEPAGE, CLEARANCE and solid insulation shall comply with the requirements of 6.7.1.101. Alternatively, the fault test of 4.4.1 may be applied instead of insulation.

R1 Separation between circuits shall provide minimum two levels of protection, as required in 6.4 and 6.5. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.2, Clause K.1 or Clause K.3.

R2 Separation between circuits shall provide minimum two levels of protection, as required in 6.4 and 6.5. Where distances are required, CREEPAGE, CLEARANCE or solid insulation shall comply with the requirements of 6.7.3, Clause K.2 or Clause K.3.

F Functional insulation. No specific level specified.

Earthed conductive parts – Shall meet the requirements of 6.5.2.4 or 6.5.2.5.

Items circled in red, on the right side, may be applied for protection against HAZARDS other than electrical shock, e.g. protection against the spread of fire (Clause 9) or protection against overtemperature or skin burn (Clause 10).

Where a HAZARDOUS LIVE circuit may be used also as a non-HAZARDOUS LIVE circuit, it shall also be investigated for all applicable insulations, and the greater requirement shall be applied across the separation.

Figure 102 – Examples of insulation between separate circuits and between circuits and ACCESSIBLE conductive parts

Add at the end of the subclause:

Between ACCESSIBLE SELV CIRCUITS, ACCESSIBLE PELV CIRCUITS or ungrounded conductive ACCESSIBLE parts and HAZARDOUS LIVE parts, there shall be two levels of protection: e.g. DOUBLE INSULATION, REINFORCED INSULATION, BASIC INSULATION + PROTECTIVE BONDING.

6.7.1.2 CLEARANCES

Replace Table 3 with the following:

Table 3 – Multiplication factors for clearances of equipment rated for operation at altitudes up to 5 000 m

RATED operating altitude m	Factor
Up to 2 000	1,00
3 000	1,14
4 000	1,29
5 000	1,48
NOTE This table is derived from IEC 60664-1:2020, Table A.2.	

Add after Table 3 the following paragraph:

Linear interpolation of the altitude factor is permitted between the nearest two points in Table 3. The calculated minimum CLEARANCE using this multiplication factor shall be rounded up to the next higher 0,1 mm increment.

6.7.1.5 Requirements for insulation according to type of circuit

Replacement:

Replace the existing text with the following:

Requirements for insulation between separate circuits and between circuits and ACCESSIBLE conductive parts are specified as follows (where the separation in question fits under more than one item, the most stringent requirement shall be used):

a) in 6.7.2 for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II with a nominal supply voltage up to 300 V;

   NOTE 1 See Annex I for nominal voltages of MAINS supplies.

   NOTE 2 Subclause 6.7.2 applies for any insulation where at least one side is connected to the MAINS circuit, supplied from a source classified as OVERVOLTAGE CATEGORY II.

   EXAMPLE 1 Between MAINS and MAINS, MAINS and secondary, or between MAINS and ACCESSIBLE surfaces.

b) in 6.7.3 for secondary circuits separated from the circuits in a) only by means of a transformer;

   NOTE 3 Subclause 6.7.3 applies for insulation between ACCESSIBLE circuits or ACCESSIBLE surfaces and other HAZARDOUS LIVE circuits, where these HAZARDOUS LIVE circuits are not directly connected to MAINS. Such circuits are generally considered as secondary circuits..

c) in Clause K.1 for MAINS CIRCUITS of OVERVOLTAGE CATEGORY III or IV or for OVERVOLTAGE CATEGORY II over 300 V;

d) in Clause K.2 for secondary circuits separated from the circuits in c) only by means of a transformer;

e) in Clause K.3 for circuits that have one or more of the following characteristics:
   1) the maximum possible TRANSIENT OVERVOLTAGE is limited by the supply source or within the equipment to a known level below the level assumed for the MAINS CIRCUIT;
   2) the maximum possible TRANSIENT OVERVOLTAGE is above the level assumed for the MAINS CIRCUIT;
   3) the WORKING VOLTAGE is the sum of voltages from more than one circuit, or is a mixed voltage;

   EXAMPLE 2 Between two circuits isolated from each other, such as MAINS and secondary, or between two secondary circuits.

   4) the WORKING VOLTAGE includes a recurring peak voltage that may include a periodic non-sinusoidal waveform or a non-sinusoidal waveform that occurs with some regularity;
   5) the WORKING VOLTAGE has a frequency above 30 kHz;

   NOTE 4 See Clause K.3 for requirements for switching circuits such as a switching power supply.

Add the following new item:

aa) Separation of SELV/PELV CIRCUITS from each other or SELV CIRCUITS to earth parts are specified in 6.7.1.101.

Requirements for insulation of measuring circuits are specified in IEC 61010-2-030.

Add the following subclause:

6.7.1.101 Separation for SELV/PELV CIRCUITS

Where separation between SELV or PELV CIRCUITS are required for protection against hazard other than electric shock, the separating insulation of SELV/PELV CIRCUITS from each other or for the separating insulation of SELV CIRCUITS to earth parts, the following shall be fulfilled.

The minimum CLEARANCES for SELV/PELV CIRCUITS are:

– for POLLUTION DEGREE 1 = 0,01 mm;
– for POLLUTION DEGREE 2 = 0,2 mm;
– for POLLUTION DEGREE 2 = 0,04 mm for printed wiring board material;
– for POLLUTION DEGREE 3 = 0,8 mm.

NOTE CLEARANCE adjustment for altitude is not necessary as corrections are negligible.

Solid insulation shall pass the voltage test of 6.8 using the test voltage of 300 V a.c. for 1 min.

For SELV/PELV CIRCUITS the CREEPAGE distances from Table 7 shall be applied.

6.7.2.1 CLEARANCES and CREEPAGE DISTANCES

Add after the first conformity statement:

Since conformity is checked by inspection and measurement, the dielectric test is not required.

Modification:

Replace Table 4 with the following:

Table 4 – CLEARANCE and CREEPAGE DISTANCES for MAINS CIRCUITS of OVERVOLTAGE CATEGORY II up to 300 V

Voltage line-to-neutral a.c. RMS	Values for CLEARANCE distances[d]			Values for CREEPAGE DISTANCES[b]								
	POLLUTION DEGREE 1	POLLUTION DEGREE 2	POLLUTION DEGREE 3	POLLUTION DEGREE 1		POLLUTION DEGREE 2				POLLUTION DEGREE 3		
				PWB MG I, II, III	MG I, II, III	PWB MG I,II,IIIa	MG I	MG II	MG III	MG I	MG II	MG III
V [c]	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
≤ 50	0,04	0,2[a]	0,8	0,04	0,18	0,04	0,6	0,85	1,2	1,5	1,7	1,9
≤ 100	0,1	0,2[a]	0,8	0,1	0,25	0,16	0,71	1,0	1,4	1,8	2,0	2,2
≤ 150	0,5	0,5	0,8	0,5	0,5	0,5	0,8	1,1	1,6	2,0	2,2	2,5
≤ 300	1,5	1,5	1,5	1,5	1,5	1,5	1,5	2,1	3	3,8	4,2	4,7

NOTE 1 This table is derived from IEC 60664-1:2020, Table F.1, Table F.2 and Table F.5.

NOTE 2 MG I = Material group I, CTI ≥ 600.

NOTE 3 MG II = Material group II, 600 > CTI ≥ 400.

NOTE 4 MG III = MG IIIa and MG IIIb.

NOTE 5 MG IIIa = Material group IIIa, 400 > CTI ≥ 175.

NOTE 6 MG IIIb = Material group IIIb, 175 > CTI ≥ 100.

NOTE 7 PWB = Printed wiring board.

NOTE 8 CREEPAGE values calculated for this table have been increased so they are not below CLEARANCE values. See footnote [b] below.

[a] For printed wiring board, the values for POLLUTION DEGREE 1 apply.

[b] Linear interpolation of CREEPAGE is allowed but CREEPAGE can never be below CLEARANCE.

[c] d.c. or a.c. peak values are $\sqrt{2} \times$ a.c. RMS values shown.

[d] Interpolation for CLEARANCES is not permitted.

Add after the last conformity statement:

NOTE See Annex FF for examples of CLEARANCES and CREEPAGE measurement special cases.

6.7.2.2.1 General

Add the following first paragraph:

If MAINS or secondary voltage is greater than 300 V, refer to Annex K.

Replace Table 5, including its title, with the following:

Table 5 – Test voltages for solid insulation between MAINS and between MAINS and secondary circuits OVERVOLTAGE CATEGORY II up to 300 V

Voltage line-to-neutral a.c. RMS V [a]	For BASIC INSULATION and SUPPLEMENTARY INSULATION Test voltages V				For REINFORCED INSULATION Test voltages V			
	a.c.		d.c.		a.c.		d.c.	
	5 s	1 min	5 s	1 min	5 s	1 min	5 s	1 min
≤ 50[b]	1 250	300	1 750	420	2 500	600	3 500	850
≤ 100[c]	1 300	350	1 800	500	2 600	700	3 600	990
≤ 150	1 350	400	1 900	570	2 700	800	3 800	1 100
≤ 300	1 500	550	2 100	780	3 000	1 100	4 200	1 600

NOTE This table is derived from IEC 60664-1:2020, 5.4.3.2.

[a] d.c. or a.c. peak values are √2 × a.c. RMS values shown.

[b] For d.c. products this range ends at 60 V.

[c] For d.c. products this range begins at 60 V.

Replace the second conformity statement, after item d), with the following:

Conformity is checked by inspection, and by the a.c. test of 6.8.3.1, or the d.c. test of 6.8.3.2, using the applicable voltage from Table 5. Both the 1 min and 5 s test shall be performed or a single test which is the worst case combination of the 1 min and 5 s tests.

NOTE 101 For example, if a 1 min test with 1,1 kV and a 5 s test with 3 kV are required, instead a single test with 3 kV and 1 min is sufficient.

6.7.3.1 General

Modification:

Add at the end of the paragraph:

For MAINS CIRCUITS above 300 V, see Annex K. For additional information on secondary circuits, see Annex CC.

6.7.3.2 CLEARANCES

Modification:

Replace Table 6 with the following:

Table 6 – CLEARANCES and test voltages for secondary circuits derived from MAINS CIRCUITS of OVERVOLTAGE CATEGORY II up to 300 V

	MAINS voltage, OVERVOLTAGE CATEGORY II					
	≤ 100 V a.c. RMS [b]		≤ 150 V a.c. RMS [b]		≤ 300 V a.c. RMS [b]	
	RATED impulse voltage 500 V		RATED impulse voltage 800 V		RATED impulse voltage 1 500 V	
Secondary WORKING VOLTAGE V a.c. RMS [b]	CLEARANCE mm [a]	Test voltage V a.c. RMS	CLEARANCE mm [a]	Test voltage V a.c. RMS	CLEARANCE mm [a]	Test voltage V a.c. RMS
10	0,04	440	0,10	500	0,47	770
12,5	0,04	440	0,10	500	0,47	770
16	0,04	440	0,10	500	0,48	830
30	0,05	455	0,11	510	0,50	840
50	0,05	455	0,12	520	0,53	860
100	0,07	476	0,13	540	0,61	900
150	0,10	507	0,16	580	0,69	940
300	0,24	641	0,39	770	0,94	1 040
600	0,79	980	1,01	1 070	1,61	1 450
1 000	1,66	1 500	1,92	1 630	2,52	1 970
1 250	2,23	1 700	2,50	1 960	3,16	2 280
1 600	3,08	2 200	3,39	2 390	4,11	2 730
2 000	4,17	2 750	4,49	2 890	5,30	3 230
2 500	5,64	3 300	6,02	3 520	6,91	3 850
3 200	7,98	4 000	8,37	4 390	9,16	4 660
4 000	10,6	4 900	10,9	5 320	11,6	5 610
5 000	13,7	6 000	14,0	6 590	14,9	6 960
6 300	17,8	8 000	18,2	8 270	19,1	8 620
8 000	23,5	10 000	23,9	10 400	24,7	10 700
10 000	30,3	12 500	30,7	12 900	31,6	13 300
12 500	39,1	15 800	39,6	16 100	40,5	16 400
16 000	52,0	20 000	52,5	20 400	53,5	20 700
20 000	67,4	25 000	67,9	25 300	68,9	25 600
25 000	87,4	31 300	87,9	31 600	89,0	32 000
32 000	117	40 400	117	40 400	118	40 700
40 000	151	50 300	151	50 300	153	50 800
50 000	196	62 800	196	62 800	198	63 400
63 000	258	79 400	258	79 400	260	80 000

[a] Linear interpolation allowed.

[b] d.c. or a.c. peak values are √2 × a.c. RMS values shown.

6.7.3.3 CREEPAGE DISTANCES

Modification:

Replace the first column heading of Table 7 of IEC 61010-1:2010 as follows:

Secondary WORKING VOLTAGE a.c. RMS

6.8.3.1 The a.c. voltage test

Addition:

Add the following first paragraph before the conformity statement:

The voltage tester shall be capable of maintaining the test voltage throughout the test within ±5 % of the specified value.

6.8.3.2 The d.c. voltage test

Addition:

Add the following first paragraph, before the conformity statement:

The voltage tester shall be capable of maintaining the test voltage throughout the test within ±5 % of the specified value.

6.9.3 Colour coding

IEC 61010-1:2010, Subclause 6.9.3 applies except as follows:

Addition:

Before the conformity statement add the following note:

NOTE In some countries green colour can be utilized instead of green-and-yellow.

Add the following subclause:

6.9.101 Wiring for SELV/PELV CIRCUITS

Wiring for SELV/PELV CIRCUITS shall be either separated from the wiring of non-SELV/PELV CIRCUITS, or the insulation of all conductors shall be RATED for the higher voltage.

Alternatively, earthed screening or additional separation shall be provided for SELV/PELV CIRCUITS or around the wiring of non-SELV/PELV CIRCUITS.

6.10 Connection to the MAINS supply source and connections between parts of equipment

IEC 61010-1:2010, Subclause 6.10 is only applicable to cord connected MAINS supply.

6.10.1 MAINS supply cords

Addition:

After the fifth paragraph add the following note:

NOTE In some countries green colour can be utilized instead of green-and-yellow.

6.11 Disconnection from supply source

IEC 61010-1:2010, Subclause 6.11 is not applicable.

NOTE IEC 61010-1:2010, Subclause 6.11 is not used for this document. Local practices and codes govern the aspect of installation and use of control equipment.

7 Protection against mechanical HAZARDS

IEC 61010-1:2010, Clause 7 and IEC 61010-1:2010/AMD1:2016, Clause 7 apply, except as follows:

Add the following subclause:

7.1.101 OPEN and PANEL MOUNTED EQUIPMENT

OPEN EQUIPMENT is intended to be installed within an ENCLOSURE which protects the OPERATOR from HAZARDS, including mechanical HAZARDS. PANEL MOUNTED EQUIPMENT may be considered as OPEN EQUIPMENT for the portion that is inside the ENCLOSURE, however, the portion of the control equipment that is not inside the ENCLOSURE and is otherwise ACCESSIBLE to an OPERATOR shall be considered to form part of an ENCLOSURE providing protection against potential HAZARDS and shall be evaluated in accordance with Clause 7.

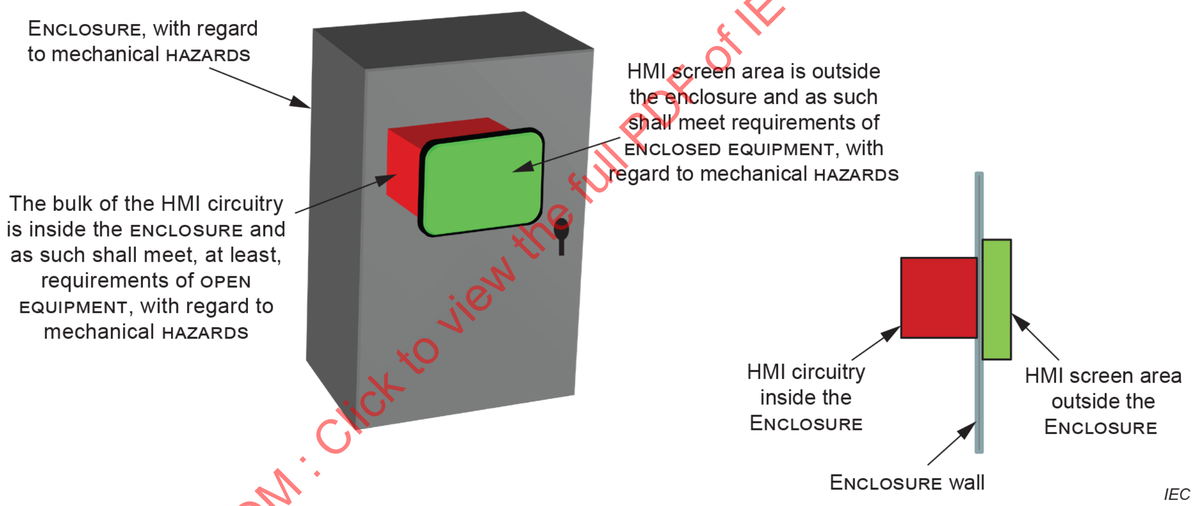


Figure 103 – Mechanical HAZARDS, with regard to PANEL MOUNTED EQUIPMENT

7.2 Sharp edges

Addition:

Consideration may be given to parts or areas uniquely accessible to service personnel.

7.3.3 RISK assessment for mechanical HAZARDS to body parts

Modification:

Add, after the first paragraph but before the conformity statement:

If a control equipment has only cooling fans as moving parts, then only a check for accessibility is necessary.

7.3.4 Limitation of force and pressure

IEC 61010-1:2010, Subclause 7.3.4 is not applicable.

7.3.5 Gap limitations between moving parts

IEC 61010-1:2010, Subclause 7.3.5 is not applicable.

7.7 Expelled parts

IEC 61010-1:2010, Subclause 7.7 is not applicable.

8 Resistance to mechanical stresses

IEC 61010-1:2010, Clause 8 applies, except as follows:

8.1 General

Modification:

Replace the second paragraph and its listed items a) to d) with the following:

The normal energy protection level is 6,8 J with a tolerance of ±5 %.

Add the following subclauses:

8.1.101 OPEN EQUIPMENT

OPEN EQUIPMENT is equipment or components, intended to be installed within an end system, where the OPERATOR is protected against exposure to HAZARDS.

NOTE An end system can be a panel or a installation rack in a restricted access location.

8.1.102 PANEL MOUNTED EQUIPMENT

PANEL MOUNTED EQUIPMENT may be considered as OPEN EQUIPMENT for the portion that is inside the ENCLOSURE, however, the portion of the control equipment that is not inside the ENCLOSURE and is otherwise ACCESSIBLE to an OPERATOR shall be considered to form part of an ENCLOSURE providing protection against potential HAZARDS and shall be evaluated in accordance with Clause 8.

8.2.2 Impact test

Modification:

Replace the fifth paragraph starting with "FIXED EQUIPMENT", with the following:

Each test point is subjected to one impact by a smooth steel sphere with a diameter of approximately 50 mm.

Replace the ninth paragraph starting with "In both cases", with the following:

The dimension X and mass are determined by the following equation: $J = X \times m \times g$

J *= 6,8 J with a tolerance of ±5 %*

$g = 10\ m/s^2$

NOTE 1 Values of the dimension *X* and mass are approximately 1,3 m and 0,5 kg using this formula.

NOTE 2 Test formula, units, etc. are derived from the pendulum test method of IEC 60068-2-75.

Add the following subclauses:

8.2.2.101 Glass displays

8.2.2.101.1 Glass display impact test

These requirements are applicable to glass displays which can cause a laceration hazard if the glass breaks and falls onto the operator.

Glass that is ACCESSIBLE:

– having a surface area exceeding 0,1 m^2; or
– having a major dimension exceeding 450 mm; or
– that prevents access to a HAZARD,

shall be subjected to the impact test of 8.2.2, Figure 10a,

with the exception of parts made of glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken.

NOTE Laminated glass includes constructions such as plastic film affixed to a single side of a glass.

EXAMPLE HMI display.

Conformity is checked by 8.1 and as follows:

The glass shall:

– *not break or crack; or*
– *not expel pieces of glass greater than 30 g in mass or greater than 50 mm in any dimension; or*
– *pass the glass display fragmentation test of 8.2.2.101.2 on a separate glass display test sample.*

8.2.2.101.2 Glass display fragmentation test

The glass display test sample is shattered with the impact test of 8.2.2, except the ball is dropped vertically onto the display surface.

Conformity is checked by 8.1 and as follows:

The impact shall be applied in a location representing the centre of the surface.

The test sample is supported per installation instructions, placed in a horizontal position, and precautions shall be taken to ensure that particles will not be scattered upon fragmentation. Without using any aid to vision, except spectacles if normally worn, the particles are counted in a square of 50 mm side located approximately at the centre of the area of coarsest fracture and excluding any area within 15 mm of any edge or hole.

The test sample shall fragment in such a way that the number of particles counted in a square with sides of 50 mm shall not be less than 45.

9 Protection against the spread of fire

IEC 61010-1:2010, Clause 9 and IEC 61010-1:2010/AMD1:2016, Clause 9 apply, except as follows:

9.2 Eliminating or reducing the sources of ignition within the equipment

Modification:

Add to item a) 1) the following note before the conformity statement:

NOTE Insulation within an energy limited circuit is considered to be functional insulation.

Add to item a) 2), at the end of the paragraph and before the conformity statement the following:

See also Figure 102.

9.3.2 Constructional requirements

Replacement:

Replace the existing text, table and figures with the following:

Application of the requirement for prevention of spread of fire shall take into consideration the type of equipment and where it is intended to be used.

– For ENCLOSED EQUIPMENT, a), b) and c) apply.
– For OPEN EQUIPMENT, a) and b) apply.

  For OPEN EQUIPMENT, where the end use location ENCLOSURE provides the protective means to comply with the requirements of c), the installation documentation shall specify the necessary constructional requirements applicable for the end use location, for example acceptable ventilation openings, as required.

  NOTE 1 End use location ENCLOSURE can be a rack or panel.

– For PANEL MOUNTED EQUIPMENT, the portion of the equipment that forms a part of the end location ENCLOSURE, shall comply with a), b), c)1), c)3) and d).

  NOTE 2 For PANEL MOUNTED EQUIPMENT the requirements of d) replace those of c)2).

  For the portion of the equipment inside the ENCLOSURE, it shall be assessed as either ENCLOSED EQUIPMENT or OPEN EQUIPMENT, and a), b), c) and d) shall be applied accordingly. See also Figure 104.

  EXAMPLE A panel mounted HMI device extending through the wall of an end location ENCLOSURE.

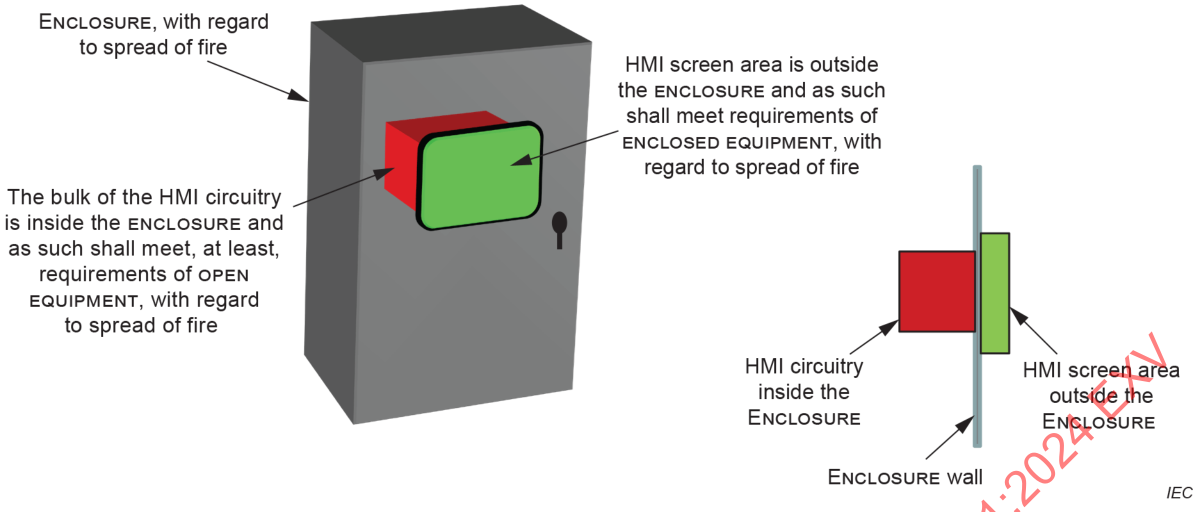


Figure 104 – Spread of fire HAZARDS, with regard to PANEL MOUNTED EQUIPMENT

a) Connectors and insulating material on which components are mounted shall have a flammability classification V-2, or better, of IEC 60695-11-10. See also 14.7 for requirements for printed wiring boards.

SELV/PELV connectors with less than 0,5 A per pin or rated current in normal condition and which contribute negligible fuel to a fire are exempted.

NOTE 3 V-0 is better than V-1, which is better than V-2.

Conformity is checked by inspection of data on materials, and, in case of doubt, by performing the vertical burning test of IEC 60695-11-10 on samples of the material used in the relevant parts.

Or optionally, conformity may be checked by a glow-wire test at 750 °C with a 30 s application and an extinguishing time less than, or equal to, 30 s in accordance with IEC 60695-2-11.

b) Insulated wires and cables shall retard flame propagation.

NOTE 4 A wire with a flammability RATING of UL 2556 VW-1 or equivalent is considered to meet this requirement.

Conformity is checked by inspection of data on materials, and, in case of doubt, by performing whichever of the following tests is applicable:

1) *for wires and cables with an overall cross-sectional area of the conductors exceeding 0,5 mm^2, the test of IEC 60332-1-2;*

2) *for wires and cables with an overall cross-sectional area of the conductors of 0,5 mm^2 or less, the test of IEC 60332-2-2.*

For equipment intended to be placed in a panel or a rack, any wires or cables interconnecting the equipment to other devices, shall also be considered.

SELV/PELV internal wires and cables carrying less than 4 A, in normal condition, and that cannot contribute to the spread of fire are exempted from the flammability requirement.

Conformity is checked by inspection or accompanying documents.

c) The ENCLOSURE shall meet the following requirements:

1) the bottom and sides of the ENCLOSURE within the 5° arc of Figure 13 of circuits that are not limited circuits according to 9.4 shall comply with one of the following requirements:

i) have no openings;

ii) be made of metal with perforations as specified in Table 16;

iii) 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;

iv) have openings with baffles in accordance with Figure 12.

2) the ENCLOSURE and any baffle or flame barrier shall be made of metal or of non-metallic materials having a flammability classification of V-1 or better, of IEC 60695-11-10. If magnesium alloy is used for the ENCLOSURE or a flame barrier, it shall be verified as specified in Annex DD.

3) the ENCLOSURE, and any baffle or flame barrier, shall have adequate rigidity, see Clause 8.

Conformity is checked by inspection. If the ENCLOSURE or flame barrier is made of magnesium alloy, the flammability test of requirement c)2) is checked as specified in Annex DD. In other cases of doubt, the flammability classification of requirement c)2) is checked by performing the vertical burning test of IEC 60695-11-10 on samples of the material used in the relevant parts.

d) For PANEL MOUNTED EQUIPMENT, the portion of the equipment that forms a part of the end use location ENCLOSURE shall be made of a material rated in accordance with, and shall comply with the following:

1) The polymeric part shall close an opening in the ENCLOSURE having an area of not more than 650 mm^2 and shall be:

– Rated V-0, V-1, or V-2; or

– Rated HB and comply with the glow wire test in accordance with IEC 60695-2-11 with a required test temperature of 750°C and with a 30 s application and an extinguishing time less than, or equal to, 30 s.

2) The polymeric part shall close an opening in the ENCLOSURE having an area of more than 650 mm^2 and shall be:

– Rated 5VA or 5VB and subjected to the resistance to mechanical stresses testing in Clause 8; or

– Rated V-0, V-1, V-2 or HB, and shall comply with the 5VA or 5VB flammability test requirement in accordance with IEC 60695-11-20.

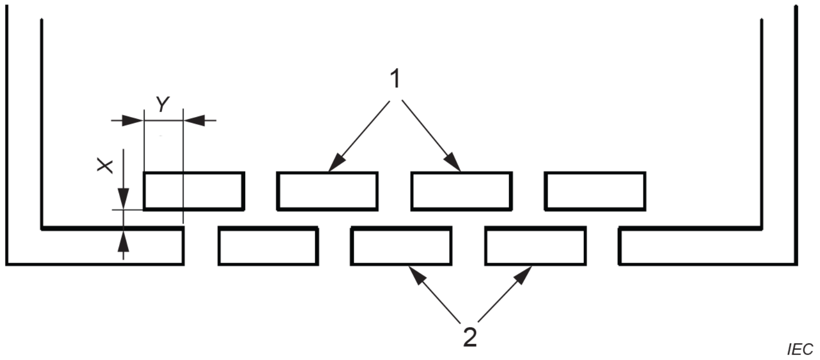
3) If magnesium alloy is used for the portion of the equipment that forms a part of the end use location ENCLOSURE, it shall be verified as specified in Annex DD.

Exception: The polymeric part is not required to be subjected to the flammability test when it encloses only parts that do not pose a risk of fire, as in 9.4 and is protected from exposure to fire by an internal metal barrier, a glass display that complies with 8.2.2.101, or polymeric barrier that complies with the flammability test. A printed wiring board rated V-0 may serve as a polymeric barrier.

Conformity is checked by inspection of the material data sheets and, if necessary, by the appropriate tests.

Table 16 – Acceptable perforation of the bottom of an ENCLOSURE

Minimum thickness mm	Maximum diameter of holes mm	Minimum spacing of holes centre to centre mm
0,66	1,14	1,70 (233 holes / 645 mm^2)
0,66	1,19	2,36
0,76	1,15	1,70
0,76	1,9	2,36
0,81	1,91	3,18 (72 holes / 645 mm^2)
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



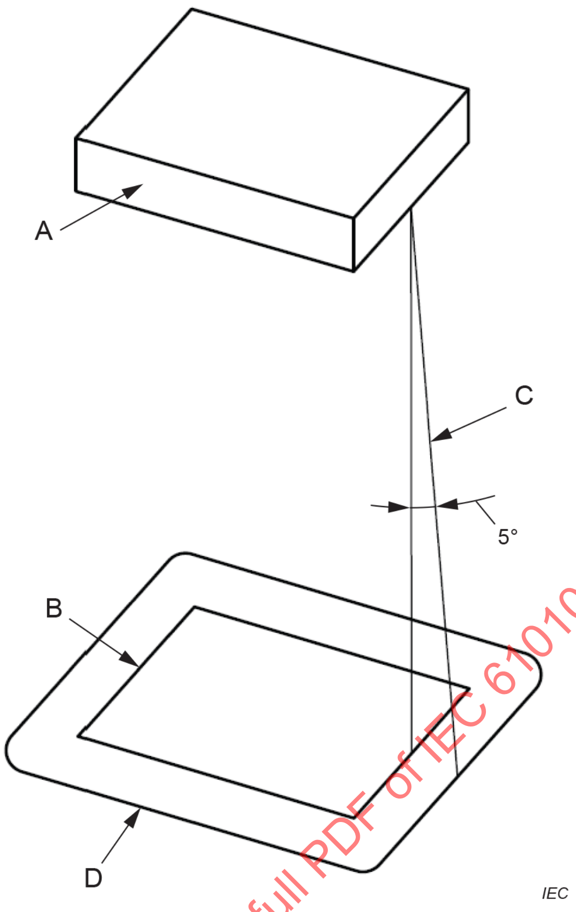
Y ≥ *X* but never less than 25 mm

Key

1 Baffle plates (may be below the bottom of the ENCLOSURE)

2 Bottom of the ENCLOSURE

Figure 12 – 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 9.3.2 c) 1) and 9.3.2 c) 2). 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 9.3.2 c) 1).

Figure 13 – Area of the bottom of an ENCLOSURE to be constructed as specified in 9.3.2 c) 1)

10 Equipment temperature limits and resistance to heat

IEC 61010-1:2010, Clause 10 and IEC 61010-1:2010/AMD1:2016, Clause 10 apply, except as follows:

10.1 Surface temperature limits for protection against burns

Modification:

Replace Table 19 with the following table and paragraph:

Table 19 – Surface temperature limits, under NORMAL CONDITION

Part	ENCLOSED EQUIPMENT °C	OPEN EQUIPMENT °C
1 Outer surface of ENCLOSURE or barrier (unintentional contact)		
a) metal uncoated or anodized	65	70
b) metal coated (paint, non-metallic)	80	85
c) plastics	85	85
d) glass and ceramics	80	85
e) small areas (< 2 cm^2) that are not likely to be touched in NORMAL USE	100	100
2 Knobs and handles (NORMAL USE contact)		
a) metal	55	55
b) plastics	70	70
c) glass and ceramics	65	70
d) non-metallic parts that in NORMAL USE are held only for short periods (1 s to 4 s)	70	85
NOTE 1 NORMAL USE contact could be surfaces touched by an OPERATOR in NORMAL USE or by SERVICE PERSONNEL.		
NOTE 2 This table is based on IEC Guide 117.		

For equipment with a RATED AMBIENT TEMPERATURE above 40 °C, higher temperatures are possible. See IEC 61010-1:2010, 10.1 and IEC 61010-1:2010/AMD1:2016, 10.1. See 5.4.4 item j) of this document.

10.3 Other temperature measurements

Modification:

Add at the end of item a):

This does not apply to control equipment FIELD WIRING, e.g. I/Os or to TERMINAL boxes for control equipment FIELD WIRING which do not contain power consuming parts.

Add the following new item aa):

aa) FIELD WIRING TERMINALS' temperature shall be monitored during the temperature test. This data shall be used in conjunction with the device's RATED AMBIENT TEMPERATURE to determine the FIELD WIRING insulation temperature requirements.

10.4.1 General

Replacement:

Replace the content of 10.4.1 by the following four new subclauses:

10.4.1 General

10.4.1.101 General method

Equipment under test (EUT) shall be tested under reference test conditions. The reference test AMBIENT TEMPERATURE *shall be the same as the maximum* RATED AMBIENT TEMPERATURE, *as defined in IEC 61010-1:2010, 1.4.1 c) or 1.4.2 c).*

NOTE 1 RATED AMBIENT TEMPERATURE can be referenced in other terminology, e.g. RATED operating temperature, or designation, such as Ta.

The installation instructions concerning ventilation, cooling liquid, limits for intermittent use, etc. are followed, unless a particular SINGLE FAULT CONDITION *specifies otherwise. Any cooling liquid shall be at the highest* RATED *temperature.*

The EUT shall be mounted in its least favourable position or orientation.

The EUT shall be generating its least favourable heat dissipation. This dissipation may be caused by some combination of load current, input voltage, input frequency, I/O duty cycle, etc.

A digital or switching output rated with a contact code designation for pilot duty shall be tested with the thermal current (I_{the}) correlating with the designation in IEC 60947-5-1:2016, Table A.1, IEC 61810-1:2015, Table B.4 or the rated load current, whichever is higher.

The EUT FIELD WIRING *shall be the smallest size suitable for the maximum current rating of the EUT in accordance with installation instructions.*

The environment surrounding the EUT during the test (volume is not a criteria) shall not be subjected to air movement caused by sources not part of the EUT, i.e. it shall be a natural convection environment. See Figure 105.

To reduce and block forced air movement in a test room or in a climatic chamber around the EUT, the EUT may be placed in a partially or completely closed test box allowing air movement or natural convection only caused by the EUT. Or barriers made of any suitable material may be used around the EUT, to block air movement.

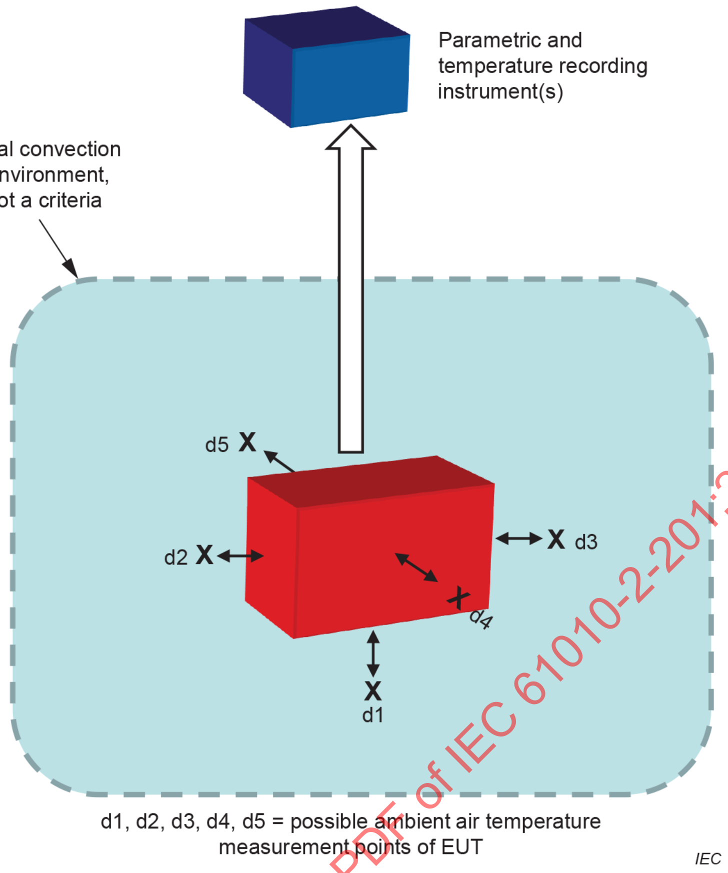


Figure 105 – General temperature test environment

Temperatures are measured when steady state has been reached. Steady state is defined as temperature rise of less than 2 K within 1 h.

If the EUT is meant to function as a stand-alone unit it shall be tested stand-alone, for example a stand-alone HMI or communication router.

If the EUT is not meant to function as a stand-alone unit, for example I/O module of a modular equipment system, then a representative system shall be utilized for testing. This system shall represent a practical least favourable combination of conditions for the EUT.

NOTE 2 A practical least favourable combination of conditions means a realistic situation the EUT can be utilized for in a real world application, not a theoretical combination which would be improbable.

This practical least favourable combination shall be, at a minimum, the items necessary for the EUT to function, for example power supply, communication module (TMs in Figure 106) and EUT. The EUT shall be surrounded, as permitted by installation documentation, on both sides with real modules or "simulation modules" (thermally representative modules, TMs in Figure 106) representing the worst case thermal environment for the EUT, i.e. adding more modules around the EUT does not cause further temperature increase of the EUT. A justification of the configuration for the test shall be provided in the test report.

An example configuration for testing an I/O module EUT, of a modular system, can be:

- *the EUT (I/O module),*
- *a power supply,*
- *communication module,*
- *three of the same type I/O module operating at full load to the left of the EUT,*
- *three of the same type I/O module operating at full load to the right of the EUT, and*
- *adding more I/O modules left or right does not cause the EUT's temperature to change.*

For vented equipment, cooled by natural air convection, the AMBIENT TEMPERATURE *is the incoming air temperature at a point not more than 50 mm and not less than 25 mm away from the plane of the equipment's air flow entry point. See Figure 106. The points d1, d2 and d3, in Figure 106, are the possible measurement points. The point with the lowest temperature should be utilized as the* AMBIENT TEMPERATURE.

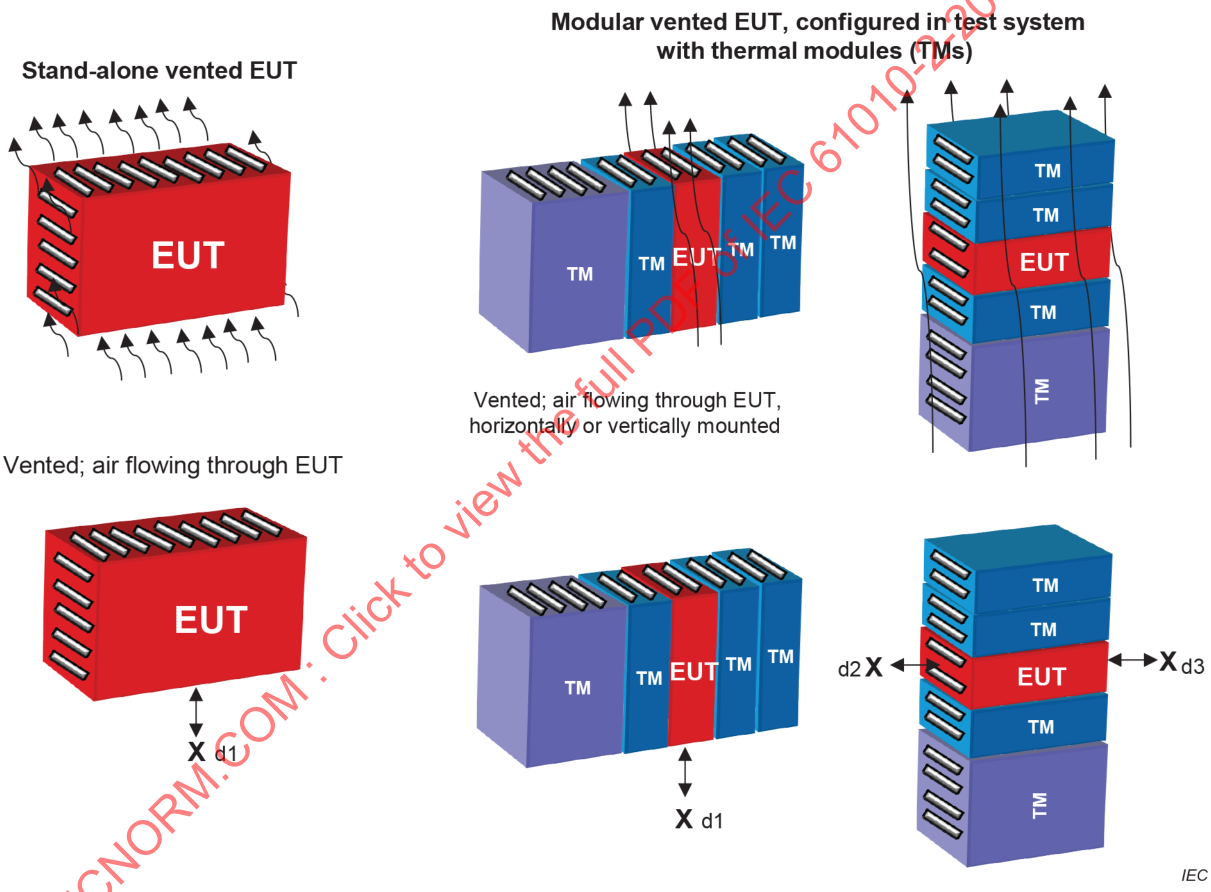


Figure 106 – Vented equipment

NOTE 3 Vents are purposeful air openings intended to enable air to pass through the equipment for the purpose of cooling, not incidental vents, e.g. switch shaft or communication jack openings.

For non-vented equipment, cooled by natural air convection, the AMBIENT TEMPERATURE *is the air temperature at a point not more than 50 mm and not less than 25 mm away from the equipment, on a horizontal plane located at the vertical mid-point of the equipment. See Figure 107. The points d2 to d5 in Figure 107 are the possible measurement points. The point with the lowest temperature should be utilized as the* AMBIENT TEMPERATURE.

Because of mounting requirements, some of the measurement points will possibly not be practical to utilize.

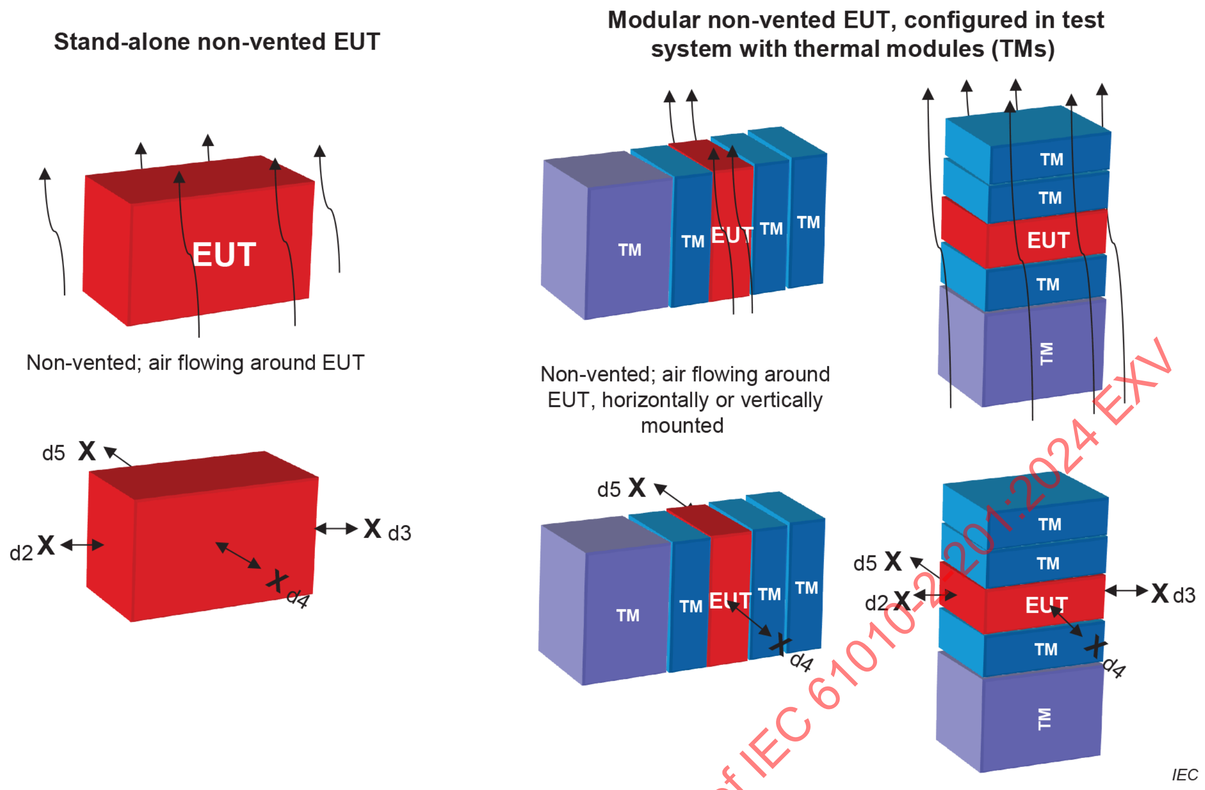


Figure 107 – Non-vented equipment

10.4.1.102 Special method, PANEL MOUNTED EQUIPMENT

PANEL MOUNTED EQUIPMENT *presents some special considerations, see Figure 108.*

In this case, part of the equipment (EUT_a) can be in one ambient environment, for example ambient environment #1 and the rest of the equipment (EUT_b) can be in another ambient environment, for example ambient environment #2. The equipment construction techniques can be quite different, for example (referring to Figure 108) open/vented in ambient environment #1 and enclosed/non-vented in ambient environment #2.

It should be kept in mind, it can be necessary that these two different environments be applied simultaneously, to ensure least favourable conditions.

Each part of the equipment (EUT_a and EUT_b) shall be evaluated separately according to its own environment.

The general method described in 10.4.1.101 with regard to test conditions and least favourable EUT configuration, orientation, etc. shall be followed.

Three special methods for testing PANEL MOUNTED EQUIPMENT *are provided:*

a) *The equipment shall be mounted such that the two portions (EUT_a and EUT_b) of the EUT are subjected to their specific environments.*

NOTE 1 This provides the most accurate results, but is the most difficult to create for a test.

b) *The total EUT (EUT$_a$ + EUT$_b$) shall be mounted in a single environment, which shall be the higher RATED temperature of the two, and the recorded temperatures of the lower RATED temperature EUT portion are corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test AMBIENT TEMPERATURE.*

EXAMPLE 1 If EUT$_a$'s maximum RATED AMBIENT TEMPERATURE = 60 °C and EUT$_b$'s maximum RATED AMBIENT TEMPERATURE = 50 °C, the test shall be run with a test AMBIENT TEMPERATURE = 60 °C. Temperatures taken for EUT$_b$ would be corrected by –10 °C (50 °C – 60 °C).

NOTE 2 This method is not as accurate as a) but will yield conservative results compared to c).

c) *The total EUT (EUT$_a$ + EUT$_b$) shall be mounted in a single environment, which shall be the lower RATED temperature of the two, and the recorded temperatures of the higher RATED temperature EUT portion are corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test AMBIENT TEMPERATURE.*

EXAMPLE 2 If EUT$_a$'s maximum RATED AMBIENT TEMPERATURE = 60 °C and EUT$_b$'s maximum RATED AMBIENT TEMPERATURE = 50 °C, the test shall be run with a test AMBIENT TEMPERATURE = 50 °C. Temperatures taken for EUT$_a$ would be corrected by +10 °C (60 °C – 50 °C).

NOTE 3 This method is not as accurate as a) and will not yield conservative results compared to b).

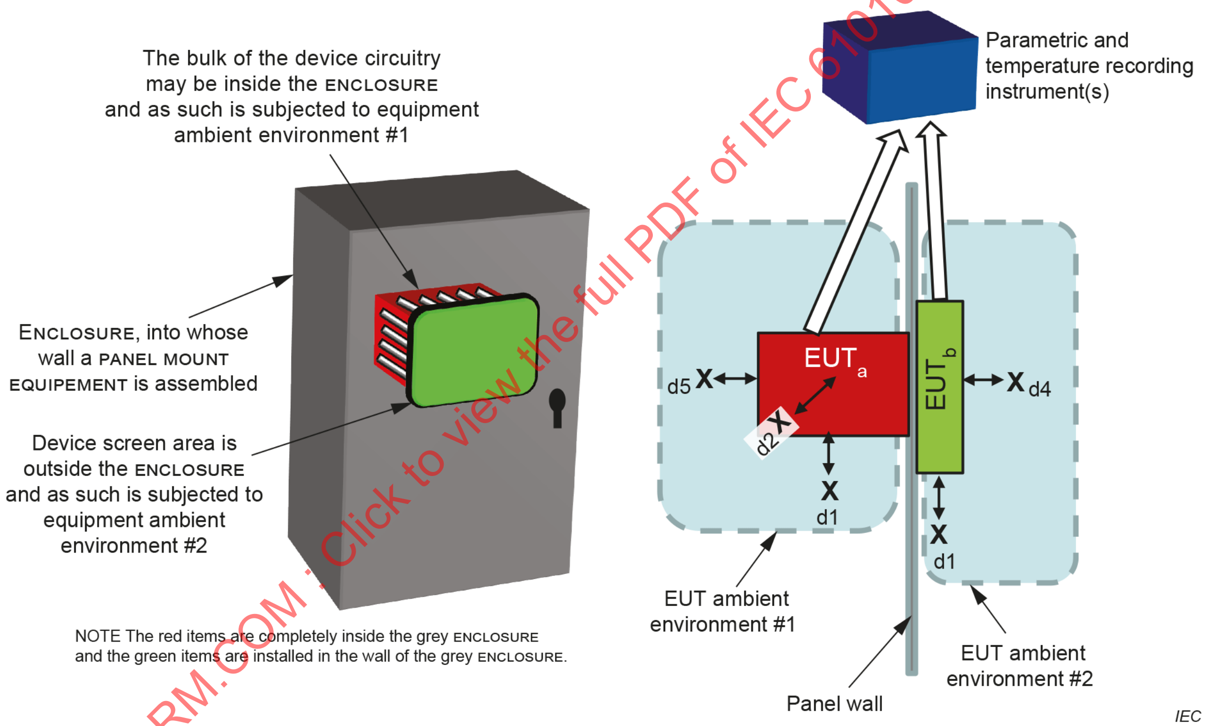


Figure 108 – PANEL MOUNTED EQUIPMENT extending through the wall of the end location ENCLOSURE

10.4.1.103 Special method, large or heavy equipment

Equipment too large or too heavy may be tested at room AMBIENT TEMPERATURE, if the recorded temperatures are corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test room AMBIENT TEMPERATURE.

Where this method is applied, a rationale shall be provided in the test report.

10.4.1.104 Other considerations, applying to all cases

Other considerations for temperature testing:

a) The temperature of insulating material of windings is measured as the temperature of winding wire and of core lamination in contact with the insulating material. It can be determined by the resistance method or by using temperature sensors selected and positioned so that they have a negligible effect on the temperature of the winding. The latter method may be used if the windings are non-uniform or if it is difficult to measure resistance.

b) Because of the difficulty of setup and repeat for single fault tests, these tests may be done at room AMBIENT TEMPERATURE. The recorded temperatures shall be corrected by the difference between the EUT's maximum RATED AMBIENT TEMPERATURE and the actual test room AMBIENT TEMPERATURE.

10.4.2 Temperature measurement of heating equipment

IEC 61010-1:2010, Subclause 10.4.2 is not applicable.

10.5.2 Non-metallic ENCLOSURES

Modification:

Add at the beginning of the subclause:

This subclause is applicable for ENCLOSED EQUIPMENT.

11 Protection against HAZARDS from fluids and solid foreign objects

IEC 61010-1:2010, Clause 11 and IEC 61010-1:2010/AMD1:2016, Clause 11 apply.

12 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure

IEC 61010-1:2010, Clause 12 and IEC 61010-1:2010/AMD1:2016, Clause 12 apply, except as follows:

12.4 Microwave radiation

Add, after the first paragraph and before the conformity statement the following:

For equipment which emits a wireless communication signal, the power density of spurious microwave radiation at frequencies between 1 GHz and 100 GHz shall not exceed 6 W/m^2 measured at a distance of 1 m.

13 Protection against liberated gases and substances, explosion and implosion

IEC 61010-1:2010, Clause 13 and IEC 61010-1:2010/AMD1:2016, Clause 13 apply, except as follows:

13.2.2 Batteries and battery charging

Addition:

Add the following note after the existing NOTE:

NOTE 101 For batteries and battery packs the following standards can additionally apply: the IEC 62133 series (battery packs), UL 1642 (lithium batteries), UL 2054 (rechargeable batteries).

14 Components and subassemblies

IEC 61010-1:2010, Clause 14 and IEC 61010-1:2010/AMD1:2016, Clause 14 apply, except as follows:

Add the following subclauses:

14.101 Components bridging insulation

14.101.1 Capacitors

A capacitor connected between two line conductors in a MAINS CIRCUIT, or between one line conductor and the neutral conductor shall comply with subclass X1 or X2 of IEC 60384-14.

A capacitor between the MAINS CIRCUIT and protective earth shall comply with subclass Y1, Y2 or Y4 of IEC 60384-14.

A capacitor bridging DOUBLE INSULATION or REINFORCED INSULATION in the control equipment shall comply with subclass Y1 or Y2 of IEC 60384-14.

In all cases a capacitor shall be used in accordance with its RATING.

These requirements do not apply to a capacitor connected between a hazardous voltage secondary circuit and protective earth, where only BASIC INSULATION is required.

Capacitors in conformity with IEC 60384-14 and approved by a recognized testing authority may be removed from the circuit for the high-voltage TYPE TEST.

Removal from the circuit is allowed, when the value of the required voltage test is higher than the rated value of the capacitor.

Compliance is checked by inspection.

14.101.2 Surge suppressors

Any surge suppressor shall, in accordance with 14.1, be suitable for the application, taking into account the impulse voltage test of 14.8.

- for OVERVOLTAGE CATEGORY II selection, AC MAINS voltage and OVERVOLTAGE CATEGORY, see Table 21; or
- for OVERVOLTAGE CATEGORY III or IV, see Clause K.4.

Where a surge suppressor(s) is bridging an isolation, an overcurrent protection shall be provided in series with the surge suppressor(s).

Where a single surge suppressor is used in the MAINS CIRCUIT, it shall be a voltage dependent resistor (VDR, also known as metal oxide varistor (MOV)).

NOTE 1 MAINS CIRCUIT can be both supply circuit and control circuits such as HAZARDOUS LIVE circuits connected to relay terminals.

It is permitted to use any type of single surge suppressor component in secondary circuits.

NOTE 2 It is not a requirement of this document to comply with any particular component standard for surge suppressors. Component requirements are given in IEC 61643 series of standards:

- IEC 61643-21 (surge suppressors in telecommunications application),
- IEC 61643-311 (gas discharge tubes),
- IEC 61643-321 (avalanche breakdown diodes),
- IEC 61643-331 (metal oxide varistors).

NOTE 3 Where the surge suppressor is not used for primary protection, see IEC 61051-2.

Compliance is checked by inspection.

14.102 Switching devices

14.102.1 General

This subclause is only applicable to switching devices with a RISK of fire or shock.

Switching devices controlling outputs shall be used within their RATINGS, according to IEC 60947-5-1 or IEC 61810-1, or equipment utilizing them shall be subjected to the overload and endurance tests specified in 14.102.2 and 14.102.3, respectively.

The closed circuit test voltage shall be 100 % to 110 % of the test voltage specified in Table 102, unless otherwise specified for the overload test.

Table 102 – Overload and endurance test voltages

	Voltage rating of switching device[a] V (a.c./d.c.)						
	110 to 120	220 to 240	254 to 277	380 to 415	440 to 480	560 to 600	660 to 690
Test voltage	120	240	277	415	480	600	690

NOTE This table is derived from IEC 61810-1:2015, Table D.5.

[a] If the rating does not fall within any of the indicated voltage ranges, it shall be tested at its maximum rated (nominal or operating) voltage.

Switching devices intended for control of single-phase motors with ratings greater than 2 horsepower (or the equivalent FLA/LRA ratings) or 3-phase motors shall be evaluated in accordance with IEC 60947-4-1 or IEC 60947-4-2 as applicable.

NOTE 1 Variable speed drive control is covered by the IEC 61800 series.

Switching devices intended for control loads other than the types indicated above or in Table 103 and Table 104 shall be tested in accordance with IEC 61810-1:2015, Annex D.

Switching devices may be tested with the specific intended load device if the load is integral to the assembly under evaluation or specified by the manufacturer and model number in the instructions.

For output devices with multiple ratings, a sufficient number of tests shall be conducted to cover the conditions of maximum voltage, maximum current, maximum power, maximum rise time ($T_{0,95}$), and minimum power factor ratings. The intent is to ensure the worst-case operating condition combination is tested.

NOTE 2 Derived from UL 508:2018, 214.2.

Outputs adjacent to the output under test shall be connected to the source polarity not likely to strike to protective earth, unless all outputs are intended to connect to the same source.

If the switching device is approved to an appropriate component standard, it may be exempted from these tests.

Conformity, pass/fail, is determined by test completion without electrical, dielectrical or mechanical breakdown of the equipment.

The dielectric test is based on the values required in 6.7 for basic isolation.

Contacts shall be monitored to detect break or make malfunctions, or both, as well as unintended bridging. Temporary malfunctions are not permitted. A temporary malfunction is an event that will self-correct, so that it does not repeat over the following test cycle. One or more failures result in failure of the endurance test.

NOTE 3 Derived from IEC 61810-1:2015, 11.1 and 11.3.

Solid-state output switching devices shall be required to establish an ON-state, to commutate, to carry designated levels of load and, if applicable, overload currents, and to establish and sustain an OFF-state condition without failure or any type of damage.

NOTE 4 Derived from IEC 62314:2006, 8.2.

14.102.2 Overload test

Switching devices shall close and open a test circuit having the current, voltage, and power factor values given in Table 103. Fifty cycles, each consisting of 1 closing and 1 opening, shall be completed using a timing of 1 s ON, 9 s OFF. After completion of the 50 cycles, the equipment shall be subjected to the endurance test in 14.102.3.

Table 103 – Overload test circuit values

Intended device application	Test current A	Power factor rise time ($T_{0,95}$)[d] ms
a.c. resistance	1,5 times device rated value[b]	1 000
d.c. resistance	1,5 times device rated value[b]	≤ 1
a.c. general use	1,5 times device rated value[b]	750 to 800
d.c. general use	1,5 times device rated value[b]	≤ 1
a.c. pilot duty [AC-15][a]	[e f]	≤ 350
d.c. pilot duty [DC-13][a]	[e f]	6 × *P* [c] ≤ 300

NOTE This table is derived from IEC 61810-1:2015, Table B.1. and Table D.1.

[a] Load utilization category as defined in IEC 60947-1:2020, Annex A or IEC 61810-1:2015, and given in brackets, is provided for reference only.

[b] Voltage shall be in accordance with Table 102.

[c] The value "6 × *P*" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to *P* = 50 W, where 6 × *P* = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value. [SOURCE: Footnotes to IEC 60947-5-1:2016, Table 4 and IEC 61810-1:2015, Table B.1.]

[d] Time to reach 95 % of the steady-state current in ms.

[e] Intended load consists of relay coil, contactor coil, or solenoid valve.

[f] Load shall be configured in accordance with the endurance test with the voltage then increased to 1,1 times the endurance test voltage.

For switching devices that are intended for control of a specific intended load device the overload test shall be conducted with the voltage increased to 1,1 times the test voltage for the endurance. When tested with specific motors, the overload test shall be conducted with the motor in the locked rotor condition.

Conformity is checked by the method in 14.102.1.

NOTE If the endurance test is to be performed, it is not necessary to do the conformity check at this point.

14.102.3 Endurance test

After completion of the overload test in 14.102.2, the switching device is to close and open a test circuit having the cycle rate, number of cycles, current, voltage, and power factor rise time ($T_{0,95}$) values given in Table 104.

It is not necessary for the endurance test to be conducted on solid-state output devices rated for general use or resistance applications only.

Switching device outputs rated with a contact code designation for pilot duty shall be tested with both the maximum operational voltage (U_e) and the maximum operation current (I_e) correlating with the designation in IEC 61810-1:2015, Table B.4.

Table 104 – Endurance test circuit values

Intended device application[b]	Test current A	Power factor rise time ($T_{0,95}$)[d] ms	Number of cycles	Test cycle time s	
				On	**Off**[f]
a.c. general use	Rated current	750 to 800	6 000	1	9
a.c. resistive	Rated current	1 000	6000	1	9
d.c. general use or resistive	Rated current	≤ 1	6 000	1	9
a.c. pilot duty[e] [AC-15][a]	Rated current	≤ 350	6 000	1[g]	9[g]
d.c. pilot duty[e] [DC-13][a]	Rated current	6 × P [c] ≤ 300	6 000	1[g]	9[g]

NOTE This table is derived from IEC 61810-1:2015, Table B.2. and Table D.2.

[a] Load utilization category as defined in IEC 60947-1:2020, Annex A or IEC 61810-1:2015, Annex B, given in brackets, is provided for reference only.

[b] Voltage shall be in accordance with Table 102.

[c] The value "6 × P" is derived from an empirical relation appropriate for most of the d.c. inductive loads up to P = 50 W, where 6 × P = 300 ms. Loads with a rated power above 50 W comprise small loads in parallel. Therefore, 300 ms is an upper limit independent of the power value. [SOURCE: Footnotes to IEC 60947-5-1:2016, Table 4 and IEC 61810-1:2015, Table B.1.]

[d] Time to reach 95 % of the steady-state current in ms.

[e] Intended load consists of relay coil, contactor coil, or solenoid valve.

[f] A shorter off time may be used if agreeable to all concerned.

[g] The first 1 000 cycles shall be at a rate of 1 cycle per second except that the first 10 to 12 cycles shall be as fast as possible.

For switching devices that are intended for control of a specific intended load, the endurance test shall be conducted with the cycle rate and number of cycles determined from Table 104 or IEC 61810-1:2015, Annex D, based on the type of load device. When tested with specific motors, the endurance test shall be conducted with the motor in the full (maximum) load condition.

The test specified in 6.7.2.2.1 between the switching output circuit(s) and other circuits shall immediately follow the endurance test or the overload test when conducted alone.

Conformity is checked by the method in 14.102.1.

15 Protection by interlocks

IEC 61010-1:2010, Clause 15 does not apply.

16 HAZARDS resulting from application

IEC 61010-1:2010, Clause 16 applies.

17 RISK assessment

IEC 61010-1:2010, Clause 17 applies.

Annexes

All annexes of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 apply, except as follows:

Annex E
(informative)

Guidelines for reduction of POLLUTION DEGREES

Replacement:

Replace the content of Annex E with the following:

The micro-environment inside the equipment is determined by the environmental conditions to which the equipment is exposed during operation, installation, maintenance, and any POLLUTION generated by the equipment itself as well as by the effectiveness of applied sealing measures.

Equipment can be divided into environmental situations as depicted in Table E.1.

Table E.1 – Environmental situations

Environmental situation	Equipment operated in ...	Installation or maintenance of equipment in ...
A	controlled environment[a]	controlled environment
B	uncontrolled environment	controlled environment or equipment is not opened during installation or maintenance
C	uncontrolled environment	uncontrolled environment
[a] A controlled environment is an environment having the conditions of IEC 61010-1:2010, 1.4.1 c) and d).		

NOTE The environmental situation of Table E.1 provides a systematic classification of the environments to which the equipment is exposed and whether the equipment can be opened for installation and maintenance purposes.

Reduction of the POLLUTION DEGREE of the micro-environment may be achieved by the methods of Table E.2. It is possible that the POLLUTION DEGREE cannot be reduced when the equipment is subject to condensation or it produces pollutants itself.

Table E.2 – Reduction of POLLUTION DEGREES (PD)

Additional protection	Original POLLUTION DEGREE						
	2			3		4	
	Environmental situation (Table E.1)						
	A	B	C	B	C	B	C
	Pollution degree with additional protection						
ENCLOSURE **IPx4**	--	--	--	--	--	--	--
ENCLOSURE **IPx5, IPx6**	1	--	--	--	--	--	--
ENCLOSURE **IPx7, IPx8**	1	1	--	2[a b]	--	2[a b]	--
Constant heating within the equipment with an ENCLOSURE **of IPx4 or higher**	1	--	--	--	--	--	--
Hermetically sealed ENCLOSURE	1	1	1	1	1	1	1

NOTE 1 Reduction maximum to PD 1.

NOTE 2 PD 3 and PD 4 not considered as controlled environment.

NOTE 3 Reduction measures are meant as alternatives.

NOTE 4 IP classification based on IEC 60529.

[a] Conformal coating, further 1 POLLUTION DEGREE reduction.

[b] Potting or encapsulation, further 1 POLLUTION DEGREE reduction.

-- = no reduction

NOTE Examples of how to use Table E.1 and Table E.2:

1) Equipment in an external environment of PD = 2 and environmental situation = B protected by an enclosure IPx7 or IPx8 gets a reduction to PD = 1.

2) Equipment in an external environment of PD = 3 and environmental situation = B protected by an enclosure IPx7 or IPx8 gets a reduction to PD = 2, and with additional protection by conformal coating gets a reduction to PD = 1.

Annex F
(normative)

ROUTINE TESTS

IEC 61010-1:2010, Annex F applies, except as follows:

F.2 Protective earth

Modification:

Add between the paragraph and the NOTE the following:

The resistance shall not exceed 0,1 Ω.

F.3.1 General

Addition:

Add the following at the beginning of the subclause:

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1 a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

F.4 Floating circuits

Addition:

Add the following at the beginning of the subclause:

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1, a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

Add the following new clause:

F.101 Supply circuits other than MAINS and floating circuits

These are supply circuits other than those defined in Clause F.3 and Clause F.4.

A test voltage is applied between

a) the supply circuit, and

b) all input and output TERMINALS of all other circuits which have to be isolated from the supply circuit in a), connected together.

During this test, the control equipment shall be electrically isolated from any external earth.

This test is not applied to small metal parts for example name plates, screws or rivets, since they are not normally connected to any circuit.

The test voltage may be a.c. or d.c. or impulse, and is selected from IEC 61010-1:2010, Table F.1 for the appropriate OVERVOLTAGE CATEGORY. For the a.c. and d.c. tests, the test voltage is raised to its specified value within 5 s, and maintained for at least 2 s. Impulse tests are the 1,2/50 µs test specified in IEC 61180, conducted for a minimum of three pulses of each polarity at 1 s minimum intervals.

No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, nor shall the test device indicate failure.

No test is required for SELV/PELV CIRCUITS/units.

No test is required for supply voltages equal to or below those specified in IEC 61010-1:2010, 6.3.1 a) and IEC 61010-1:2010/AMD1:2016, 6.3.1 a).

Annex L
(informative)

Index of defined terms

This annex of IEC 61010-1:2010 does not apply.

See IEC 61010-1:2010, Clause 1 and Clause 3 of this document for a complete set of defined terms.

Add the following new annexes:

Annex AA
(informative)

General approach to safety for control equipment

AA.1 Personnel

AA.1.1 General

There are two types of persons whose safety it is necessary to consider, OPERATORs and SERVICE PERSONNEL. Figure AA.1 depicts the general situation.

NOTE SERVICE PERSONNEL is described in Clause 3.

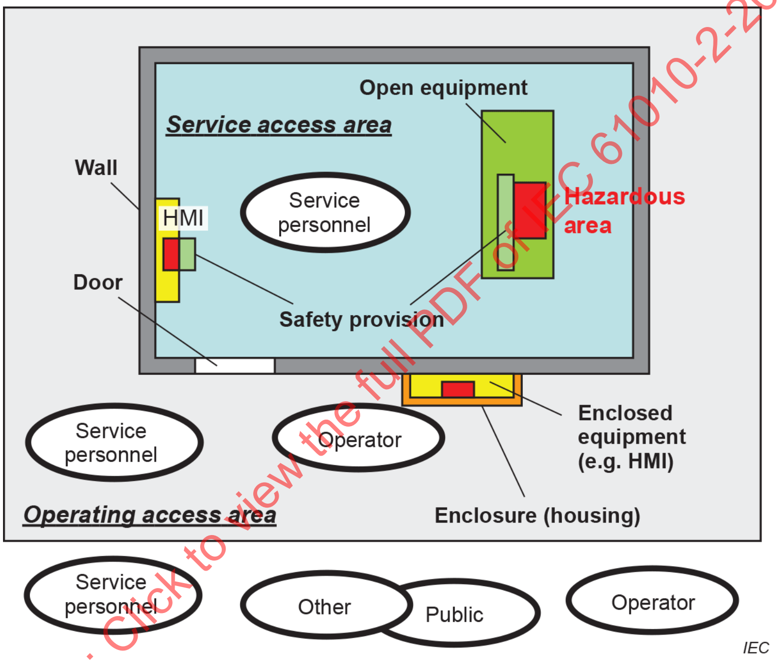


Figure AA.1 – Control equipment access and safety concerns

AA.1.2 OPERATOR

OPERATOR is the term applied to all persons other than SERVICE PERSONNEL. Requirements for protection should assume that OPERATORs are not trained to identify HAZARDS, but will not intentionally create a hazardous situation. Consequently, the requirements will provide protection for cleaners and casual visitors as well as the assigned OPERATORS. In general, OPERATORs should not have access to hazardous parts, and to this end, such parts should only be in service access areas or in ENCLOSED EQUIPMENT located in operating access areas.

AA.1.3 SERVICE PERSONNEL

SERVICE PERSONNEL are expected to use their training and skill to avoid possible injury to themselves and others due to obvious HAZARDS that exist in service access areas of the control equipment or on ENCLOSED EQUIPMENT located in operating access areas. However, SERVICE PERSONNEL should be protected against unexpected HAZARDS.

This may be done by, for example:

- locating parts that require to be ACCESSIBLE for servicing away from areas with electrical and mechanical HAZARDS;
- providing shields to avoid accidental contact with hazardous parts;
- providing interlocks as protection against HAZARDS;
- providing labels or instructions to warn personnel about any residual RISK.

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

There can be requirements for SERVICE PERSONNEL to be licensed or certified for the equipment they service.

AA.2 Operating access areas

This is meant as the control equipment location. SERVICE PERSONNEL have access to these areas and OPERATORS may be allowed depending on the level of training or instruction necessary for access. This can be a room or a cabinet, for example.

AA.3 Service access areas

These are areas of the control equipment where service tasks are expected to be performed, i.e. changing fuses, batteries, cleaning filters, performing isolation tests. Only SERVICE PERSONNEL have access. This can be a room or a cabinet, for example. These areas are normally secured.

AA.4 Equipment types

AA.4.1 General

Two types of control equipment are available. These have different constructional requirements. These are meant for use by different personnel or installation, or both, in different areas. These two control equipment types are OPEN and ENCLOSED EQUIPMENT.

AA.4.2 OPEN EQUIPMENT

OPEN EQUIPMENT is meant for access only by SERVICE PERSONNEL. It provides protection for SERVICE PERSONNEL against unintentional contact with:

a) unexpected HAZARDOUS LIVE parts;
b) unexpected hot surfaces, as opposed to expected hot surfaces such as heat sinks and semiconductors;
c) unexpected mechanical HAZARDS, such as sharp edges, protruding wires and screws, as opposed to expected mechanical hazards such as fans.

AA.4.3 ENCLOSED EQUIPMENT

ENCLOSED EQUIPMENT is meant for access by an OPERATOR. It provides protection for the OPERATOR in NORMAL CONDITION and SINGLE FAULT CONDITION against:

a) contact with HAZARDOUS LIVE parts;

b) hot surfaces;

c) mechanical HAZARDS.

NOTE The ENCLOSURE can be used to prevent spread of fire, from the ENCLOSED EQUIPMENT, if the ENCLOSURE is designed for that purpose.

Annex BB
(informative)

System drawing of isolation boundaries

BB.1 General

The intent of Annex BB is to foster a consistent use of this document by designers and certifiers.

One concept discussed is a kind of system drawing, which can be used to understand and communicate the electrical safety and isolation in a system as it is developed. This drawing can then help inform future designers and certification parties, working on the system, of the concepts originally set down.

This annex will focus on OPEN EQUIPMENT. The figures shown in this annex are examples and serve for illustration of the text.

The following pictures in this annex only deal with electric shock aspects.

BB.2 Installation environment of OPEN control equipment

Figure BB.1 depicts an example of a typical ENCLOSURE. The ENCLOSURE contains multiple items which comprise parts of the overall automation system.

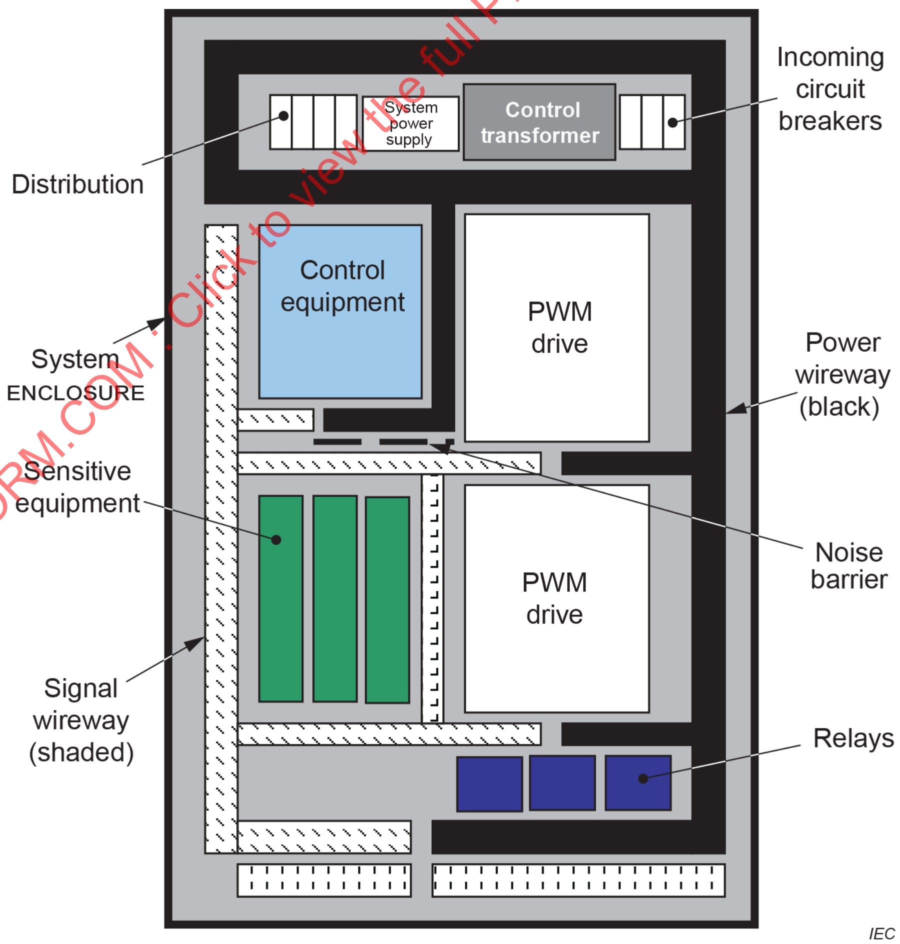


Figure BB.1 – Typical system ENCLOSURE layout

The incoming circuit breakers are shown near the top of the ENCLOSURE. This may be the factory three-phase distribution a.c. power, for example 480 V a.c.. Next to this is a control transformer illustrated. This is used to step down the factory power to local control power, for example 480 V a.c. three phase to single phase 120 V a.c..

The system power supply, which utilizes the local control power to provide control equipment power, for example 24 V d.c. is located to the left of the control transformer. Located close by these items, would be power distribution circuit breakers and TERMINALS so as to distribute the local control and control equipment power within the ENCLOSURE. Note these items are normally located near the top of the ENCLOSURE to keep their heat production from affecting more heat sensitive equipment below.

Located on the right side of the ENCLOSURE are a set of PWM drives, which are not the subject of this document, see the IEC 61800 series. However it is typical to see such an automation system configuration.

More sensitive equipment (sensitive from a temperature or of EMC noise perspective, or both) is normally located near the bottom of the ENCLOSURE.

The subject of this document, control equipment, is located at the left centre. It is more temperature and noise tolerant, but not as insensitive as those items near the top of the ENCLOSURE.

Note the wireway organization. It is laid out to segregate wiring by type; for example high power, higher voltage, noise prone wiring in the black wireway and low power, low voltage, low noise wiring in the shaded wireway. Note also the noise barrier where it is necessary for high power/noise and low power/noise wiring to be in close proximity.

BB.3 Control equipment electrical safety drawing

Utilizing the general layout just discussed, and focusing on the control equipment, it is possible to create a generalized schematic of the environment in which the control equipment resides. Figure BB.2 represents an example schematic for what can be called a control equipment electrical safety drawing.

This diagram can provide a key item in the design of any control system, the environment and the method by which that system will achieve protection against electrical shock hazards.

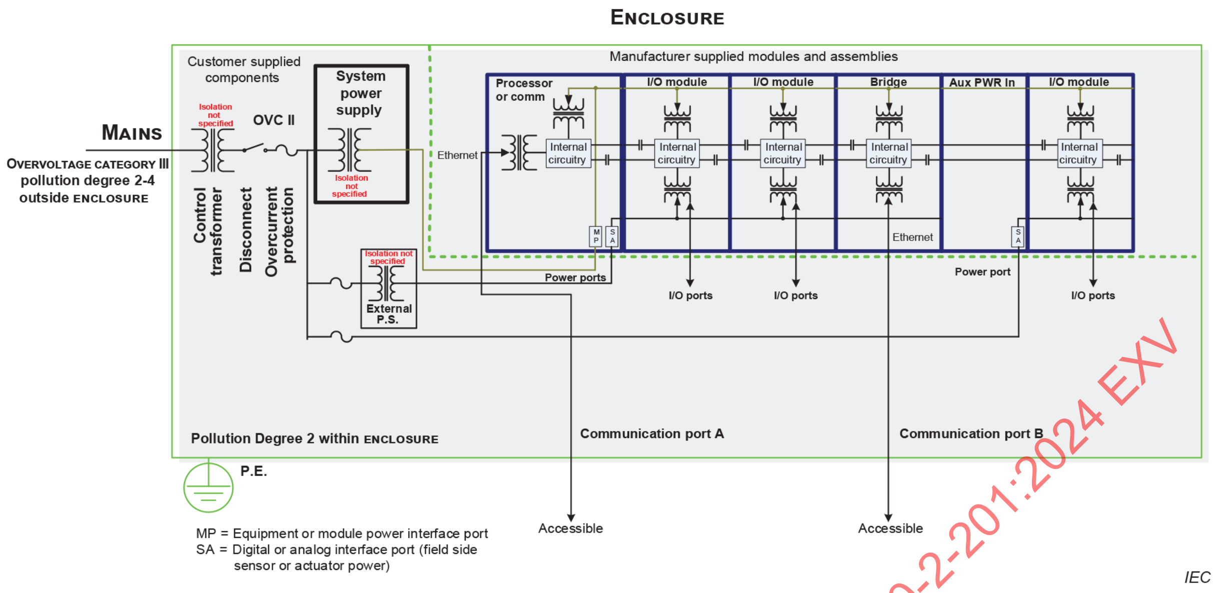


Figure BB.2 – Simplified system schematic

The control equipment, which is being discussed, is within the dashed green box and referred to as "manufacturer supplied modules and assemblies". This is the equipment being designed with the help of this document. As this example is a modular system, a number of example modules, for example processor or communication module, I/O module, bridge (another type of communication module) and a power input module are shown. Many other types of modules are possible. See Figure 101.

Since this example is OPEN EQUIPMENT, it is shown housed inside the ENCLOSURE. This is generally a larger ENCLOSURE into which many different equipment items are housed. See Figure BB.1.

The two lines exiting the ENCLOSURE, in Figure BB.2 to Figure BB.11, are communications lines normally ACCESSIBLE by personnel, for example OPERATORS, or interfaced to other equipment, for example PWM drives. As these items can be ACCESSIBLE by OPERATORS, protection is provided. See communication ports for example Ar, Be or E in Figure 101 and Table 101.

Each of the modules, for example processor or communication module, I/O module, bridge or auxiliary power input module, may have other ports where connection is made to the module. I/O ports are shown in the schematic, for example C or D in Figure 101 and Table 101. And power ports are also shown, for example F or J in Figure 101 and Table 101.

At the top of each module a transformer is shown. This is used to schematically indicate isolation between power entering at the top and the "internal circuitry" fed from the transformer. Similarly at the bottom of the side of each module is another transformer symbol. Again this indicates the isolation between the "internal circuitry" and the power and circuitry which may be on the opposite side.

"Internal circuitry" is that circuitry, for example microprocessor or memory, which is internal to the module and sits inside a sort of isolation island formed by the indicated transformers. Hence it can be said the internal circuitry is isolated from the outside world.

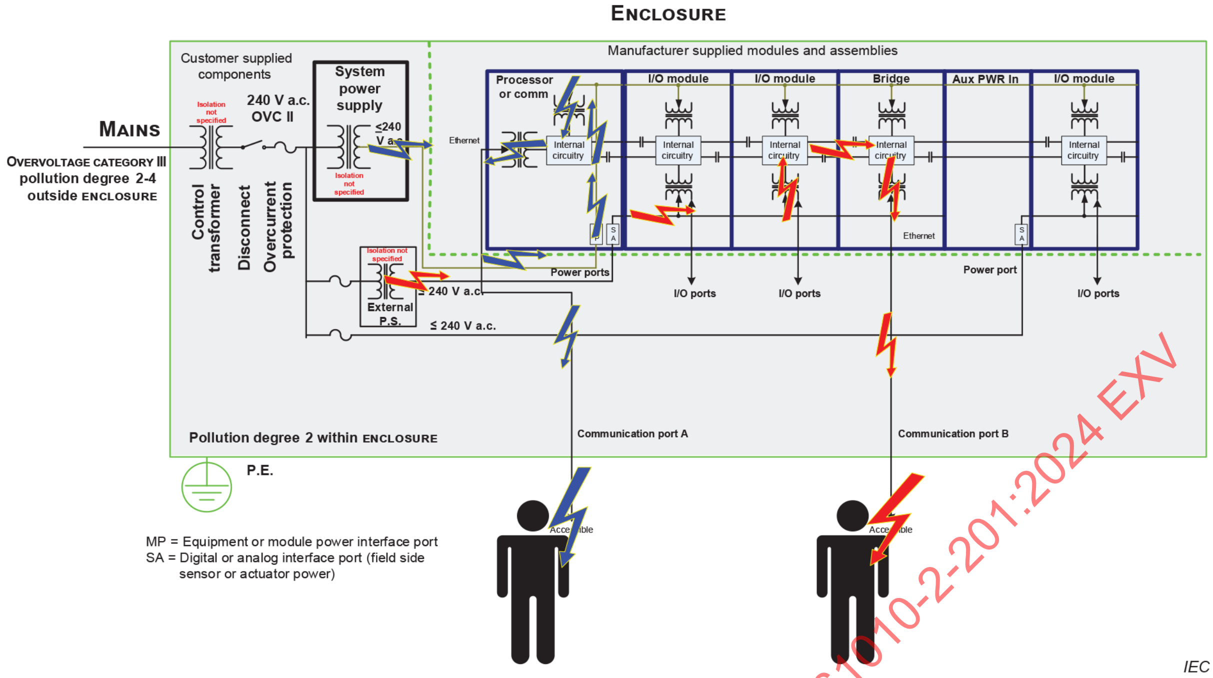


Figure BB.3 – HAZARD situation of the control equipment

Figure BB.3 depicts two example situations for the safety aspects provided in Figure BB.2.

Following the blue lightning bolts, representing a hazardous voltage, the voltage is shown entering a power port. If there are failures of the processor module isolation devices or they do not exist, then the person working on the communication port A will be exposed to the hazardous voltage.

Similarly, again referring to Figure BB.3, following the red lightning bolts, also representing a hazardous voltage, the voltage is shown entering a different power port. If there are failures of the I/O module and bridge isolation devices or they do not exist, then the person working on the communication port B will be exposed to the hazardous voltage.

BB.4 Applying IEC 61010-2-201 to the control equipment electrical safety drawing

Figure BB.4, Figure BB.5 and Figure BB.6 provide a reference for establishing which clauses of this document apply to which areas of the control equipment electrical safety drawing.

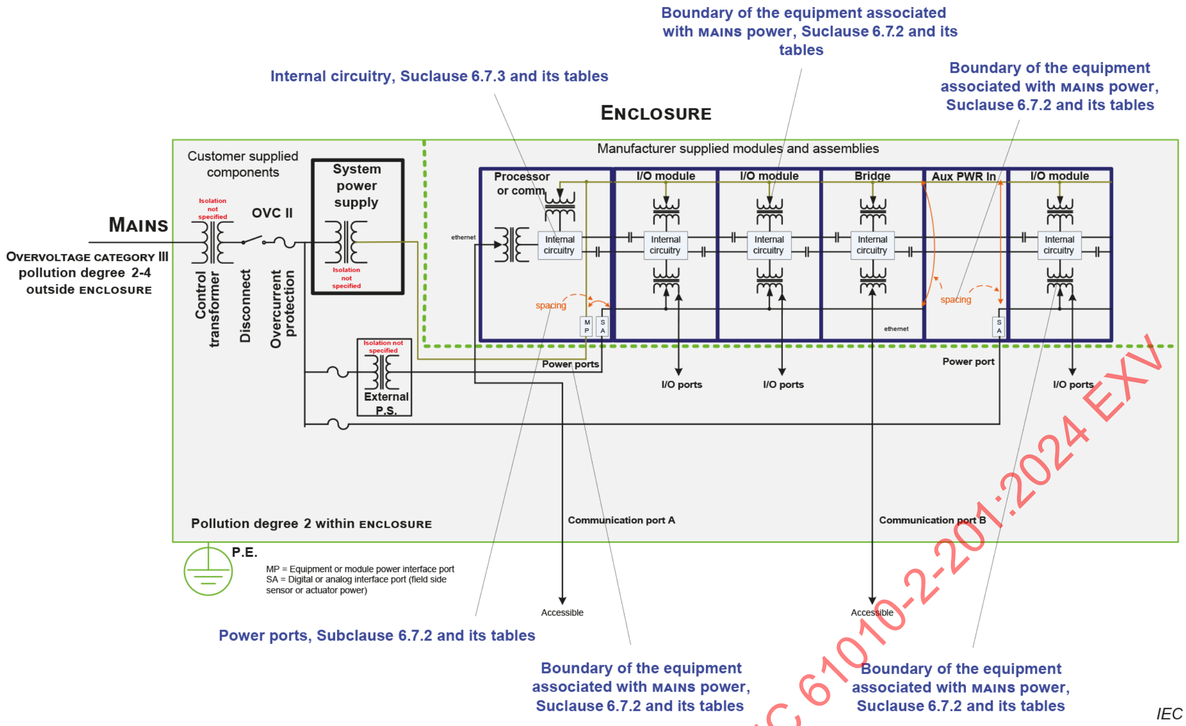


Figure BB.4 – Application of IEC 61010-2-201 to the control equipment safety drawing

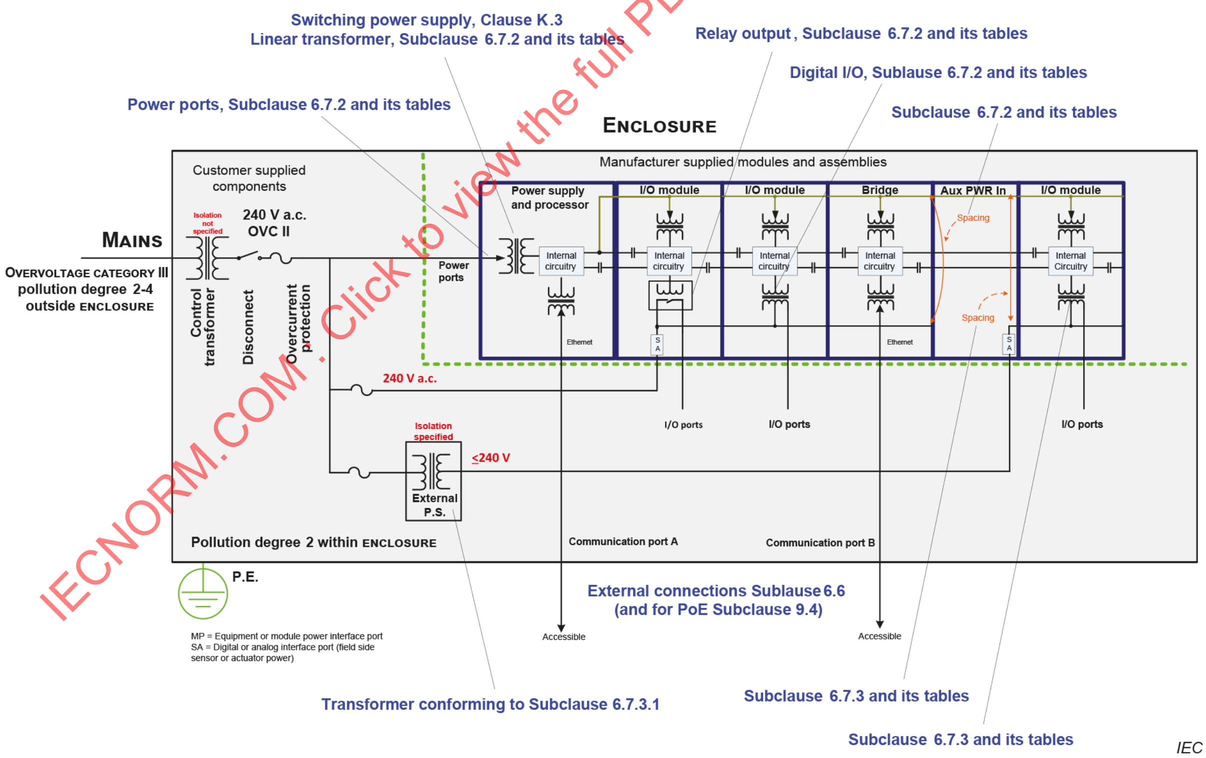


Figure BB.5 – Application of 6.7.1.5 items a) and b) to the control equipment safety drawing

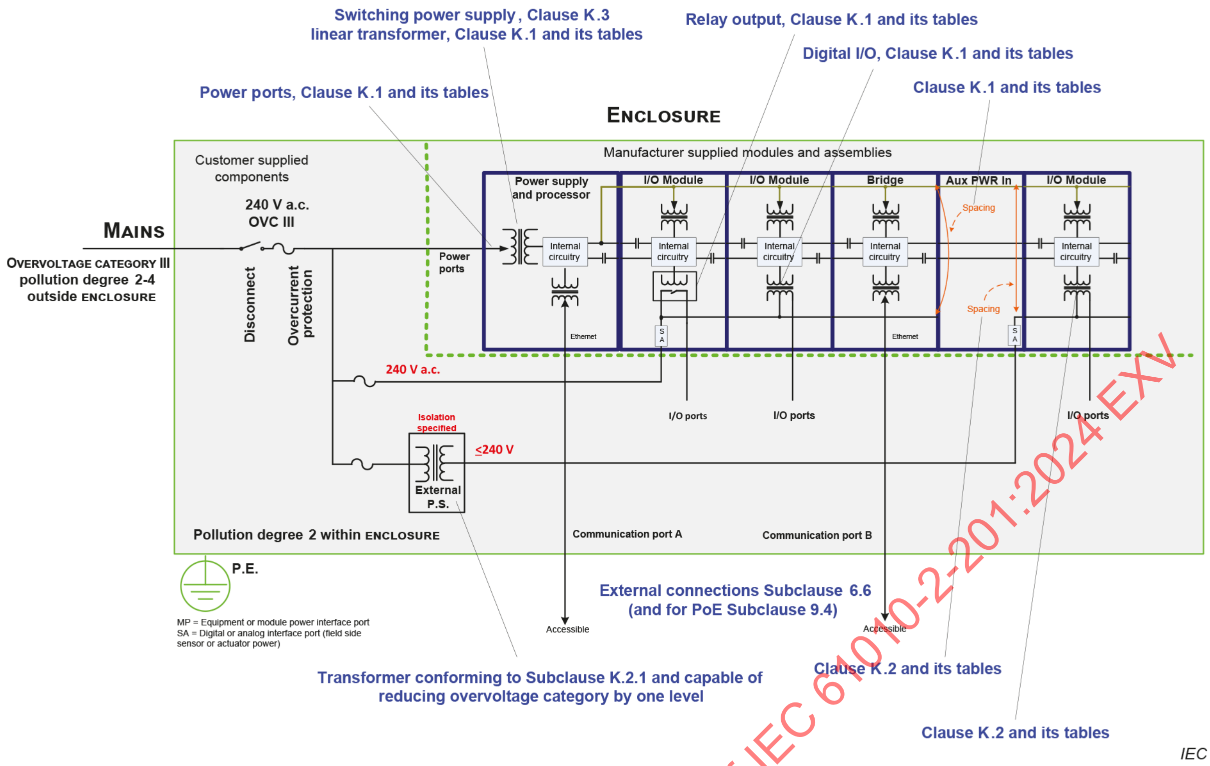


Figure BB.6 – Application of 6.7.1.5 items a), b), c) and d) to the control equipment safety drawing

For this document, the equipment shall be safe under normal and SINGLE FAULT CONDITION. Some examples of different methodologies to make the schematic in Figure BB.3 safe are now presented.

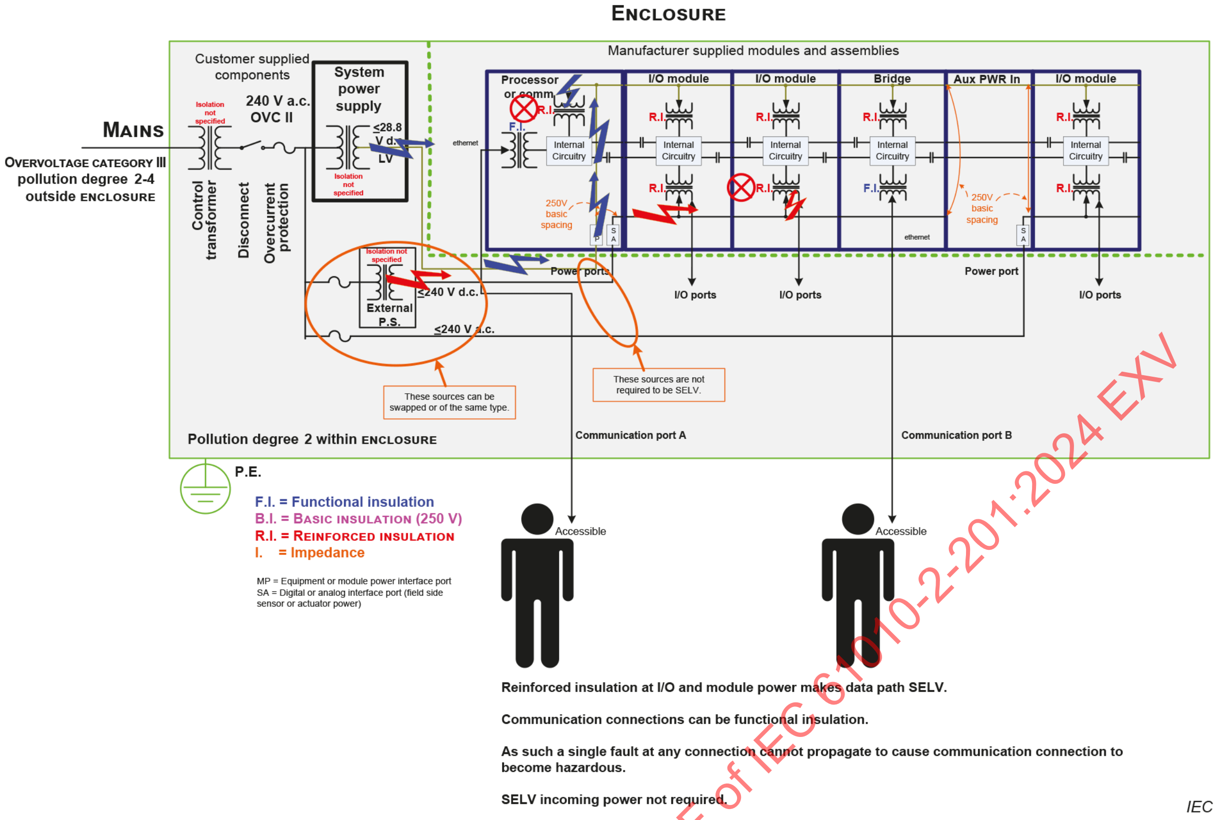


Figure BB.7 – REINFORCED INSULATION

Referring to Figure BB.7, REINFORCED INSULATION provides the method to handle single faults and maintain safety.

REINFORCED INSULATION at I/O and module power makes the ACCESSIBLE communication ports SELV/PELV.

Communication connections can utilize functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

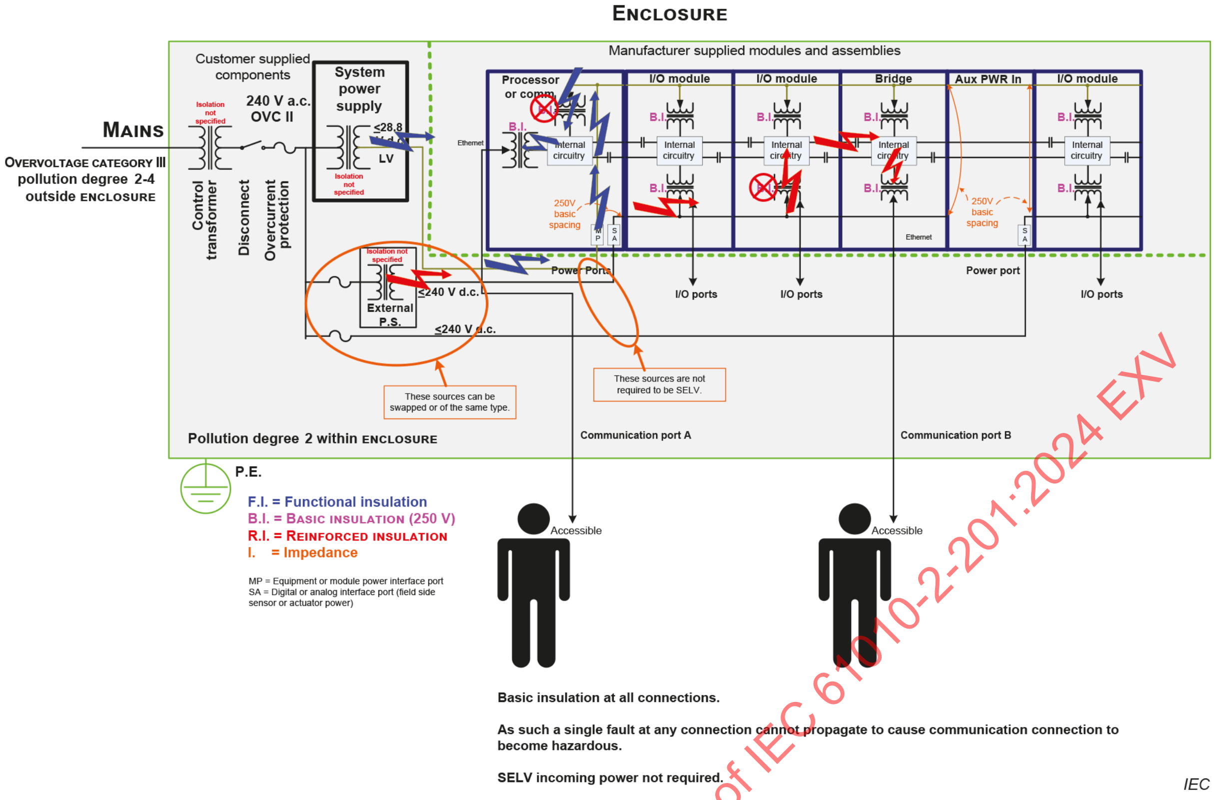


Figure BB.8 – BASIC INSULATION

Referring to Figure BB.8, BASIC INSULATION provides the method to handle single faults and maintain safety.

BASIC INSULATION is provided at all connections. One failure of a BASIC INSULATION is allowed, but a second level of BASIC INSULATION is always present.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

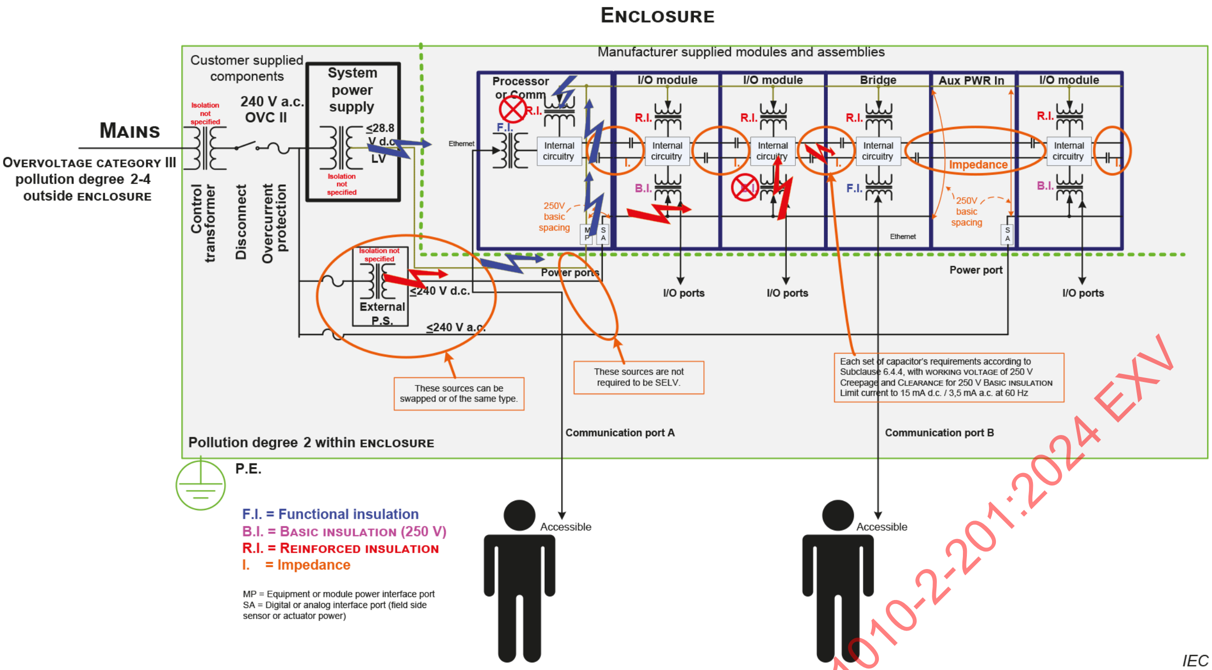


Figure BB.9 – REINFORCED INSULATION, BASIC INSULATION and impedance

Referring to Figure BB.9, REINFORCED INSULATION, BASIC INSULATION and impedance provide the method to handle single faults and maintain safety.

REINFORCED INSULATION is provided at module power. Impedance, by inter-module capacitors, and basic (supplementary) insulation is provided at the I/O.

Communication connections can be functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

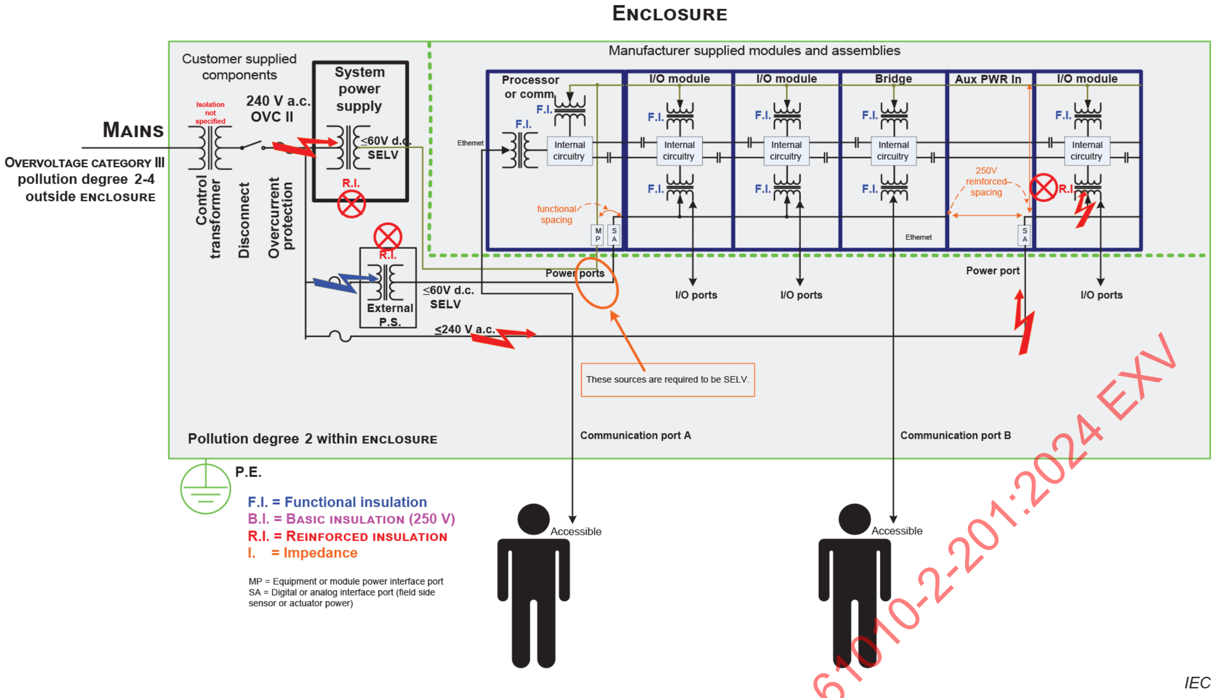


Figure BB.10 – REINFORCED INSULATION from external power supplies

Referring to Figure BB.10, external power supplies provide REINFORCED INSULATION with SELV/PELV output levels and hence provide the method to handle single faults and maintain safety.

I/O, communication connections can be functional insulation, as they are not required to provide any protection.

REINFORCED INSULATION is necessary wherever any non-SELV/PELV power is applied, for example a.c. I/O.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

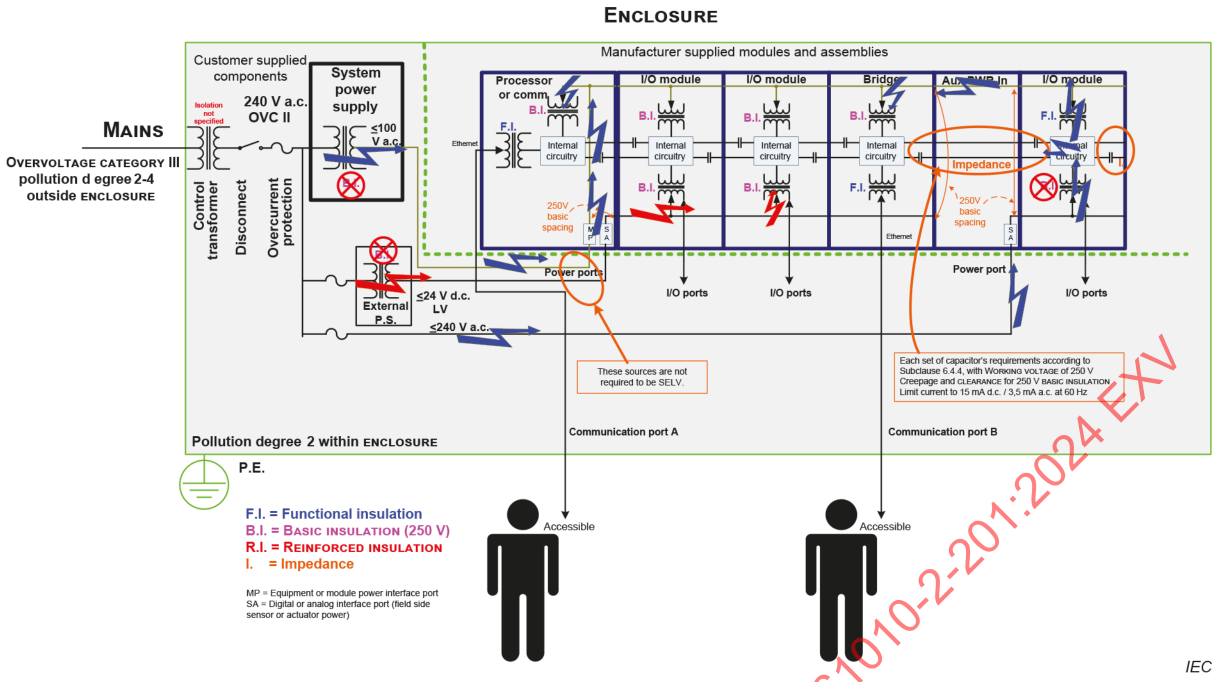


Figure BB.11 – BASIC INSULATION from external power supplies

Referring to Figure BB.11, external power supplies provide BASIC INSULATION and hence provide a method to handle single faults and maintain safety.

BASIC INSULATION is also provided at all connections I/O. One failure of a BASIC INSULATION at the power supplies is allowed, but a second level of BASIC INSULATION is always present, at the I/O.

Impedance, by inter-module capacitors, and BASIC INSULATION can also be provided at the I/O. In this way a first failure is protected against.

Communication connections can be functional insulation, as they are not required to provide any protection.

As such, a single fault at any connection cannot propagate to cause communication connections to become hazardous.

Implementation of the associated safety methods in this example makes the use of SELV/PELV as a protection method unnecessary, but still permissible.

These five scenarios are just a few of many which may be the basis for control system electrical safety.

Whatever the method chosen, it is recommended the method be documented in a drawing, such as shown here.

BB.5 Conclusion

The development of a control equipment electrical safety drawing is invaluable in understanding and communicating the electrical safety and isolation in a system as it is developed. This can keep all parties involved in the original certification, as well as future participants making additions to an expandable system, on a consistent path.

Annex CC
(informative)

Historical techniques for secondary circuits

CC.1 Secondary circuits background

Annex CC is meant to describe a set of circuits utilized historically in control equipment. These techniques are not recommended for new designs. Newer techniques have been devised and accepted into common practice eliminating the need for these circuits.

This annex is an overview and is not meant to be a complete description of these circuits, the techniques nor the requirements and conditions to utilize them. For a complete set of information on these circuits, see UL 508.

The circuits listed offer two areas of effect: controlling the provisions against electric shock and against spread of fire.

CC.2 Secondary circuits without RISK of electrical shock

CC.2.1 General

The following secondary circuits also do not pose a RISK of electrical shock and do not require additional evaluation for RISK against electrical shock:

a) class 2 circuit;
b) circuits with limited voltage and current (limited voltage/current circuits);
c) limited voltage circuit;
d) limited energy circuit that involves open circuit potential less than or equal to 30 V a.c. or 42,4 V peak;
e) limiting impedance circuit.

These circuits are described in CC.2.2.1, CC.2.2.2, CC.2.2.3, CC.2.2.4 and CC.2.2.5.

CC.2.2 Secondary circuits which do not pose a RISK of electrical shock

CC.2.2.1 Class 2 circuit

A class 2 circuit shall be supplied by an isolating source, providing DOUBLE INSULATION or REINFORCED INSULATION, which has a maximum output voltage of 42,4 V peak (sinusoidal or non-sinusoidal a.c.) or 60 V for continuous d.c. or 24,8 V peak for d.c. interrupted at a rate of 200 Hz or less with approximately 50 % duty cycle.

The maximum output current of a class 2 source depends on whether it is inherently limited or not inherently limited. For inherently limited sources, Table CC.1 applies. For not inherently limited sources, Table CC.2 applies.

CC.2.2.2 Limited voltage/current circuit

A circuit with limited voltage and current (limited voltage/current circuit) shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, in such a way that the maximum open-circuit voltage available to the circuit is not more than a.c. 30 V RMS and 42,4 V peak and the current available is limited to a value not exceeding 8 A measured after 1 min of operation.

The secondary winding of an isolating type transformer may be used to comply with this requirement.

A secondary fuse or other such secondary circuit protective device used to limit the available current shall be RATED at no more than 5,0 A for a circuit RATED less than, or equal to, 20 V peak, or 100 VA for a circuit RATED from 20 V to 30 V peak.

If the current-limiting device is provided in the MAINS CIRCUIT, there are no restrictions on its current RATING as long as it limits the available secondary current to 8 A.

CC.2.2.3 Limited voltage circuit

A limited voltage circuit shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, with a maximum open-circuit voltage of not more than a.c. 30 V RMS and 42,4 V peak without any limitation on the available current or volt-ampere capacity.

Overcurrent protection shall be provided to protect against burnout and damage to the insulation resulting from any overload or short-circuit condition. This protection may alternately be provided in the MAINS CIRCUIT by overcurrent protective devices provided with the control equipment or by branch circuit devices.

CC.2.2.4 Limited energy circuit which involves open-circuit potential less than, or equal to, a.c. 30 V RMS and 42,4 V peak

A limited energy circuit shall be supplied by an isolating source, providing DOUBLE or REINFORCED INSULATION, in such a way that the maximum volt-ampere capacity available to the circuit is 200 VA or less at a maximum open-circuit voltage of less than or equal to a.c. 30 V RMS and 42,2 V peak. The secondary winding of an isolating type transformer may be used to comply with this requirement. A primary or secondary fuse or other circuit protective device may be used to limit the maximum volt-ampere capacity.

CC.2.2.5 Limiting impedance circuit

A limiting impedance circuit shall be supplied by an impedance that complies with the following two requirements:

a) the calculated power dissipation of the impedance, as the result of a direct short applied across the circuit downstream of the impedance, does not exceed the power RATING of the impedance, and
b) the power dissipated in the impedance shall be less than 15 W.

If the above calculated power dissipation exceeds the RATING of the impedance, the impedance may still be used if the power is less than 15 W and if the impedance does not open or short when subjected to a direct short applied across the circuit downstream of the impedance.

The limiting impedance shall be able to function under SINGLE FAULT CONDITION unless the circuit limited by the impedance is enclosed.

A single resistor, or a single across-the-line capacitor approved per 14.101.1, is considered to comply with this limiting impedance requirement.

CC.3 Secondary circuits without RISK of spread of fire

CC.3.1 General

The following secondary circuits also do not pose a RISK of spread of fire and do not require additional evaluation for RISK of spread of fire:

a) class 2 circuit;

b) limited voltage/current circuit;

c) limiting impedance circuit;

d) limited power circuit.

CC.3.2 Secondary circuits which do not pose a RISK of spread of fire

CC.3.2.1 Class 2 circuit

See CC.2.2.1.

CC.3.2.2 Circuit with limited voltage and current (limited volage/current circuit)

See CC.2.2.2.

CC.3.2.3 Limiting impedance circuit

See CC.2.2.5.

CC.3.2.4 Limited power circuit

A limited power circuit is a circuit supplied by sources such as a battery or a transformer winding where the open-circuit potential is not more than a.c. 30 V RMS and 42,4 V peak or d.c. 60 V, and the energy available to the circuit is limited according to one of the following means:

a) the maximum output current and power are inherently limited to not more than the values of Table CC.1;

b) the maximum output current under all conditions and power are limited by impedance to be not more than the values of Table CC.1;

c) an over-current protective device limits the maximum output current and power to not more than the values of Table CC.2;

d) a regulating network limits the maximum output current and power to not more than the values of Table CC.1 in NORMAL USE or as a result of one fault in the regulating network; or

e) a regulating network limits the maximum output current and power to not more than the values of Table CC.1 in NORMAL USE, and an over-current protective device limits the output current and power to not more than the values of Table CC.2 as the result of any one fault in the regulating network.

Where an over-current protective device is used, it shall be a fuse or a non-adjustable non-self-resetting device.

Table CC.1 – Limits of output current and output power for inherently limited power sources

Open-circuit output voltage *U*		Maximum output current	Maximum output power
a.c. V RMS	d.c. V	A	VA
≤ 20	≤ 20	8,0	5 × *U*
20 < *U* ≤ 30	20 < *U* ≤ 30	8,0	100
	30 < *U* ≤ 60	150/*U*	100

For non-sinusoidal a.c. and for d.c. with ripple exceeding 10 %, the peak voltage shall not exceed 42,4 V peak.

Table CC.2 – Limits of output current, output power and RATINGS for over-current protective devices for non-inherently limited power sources

Open-circuit output voltage *U*		Maximum output current	Maximum output power	RATED current value of over-current protective device
a.c. V RMS	d.c. V	A	VA	A
≤ 20	≤ 20	1 000/*U*	250	≤ 5
20 < *U* ≤ 30	20 < *U* ≤ 60	1 000/*U*	250	≤ 100/*U*

RATED current values for over-current protective devices are for fuses and circuit-breakers which break the current within 120 s at a current value of 210 % of the value in the last column of Table CC.2.

Conformity is checked by measuring the output voltage, the maximum output current and the maximum available output power under the following conditions:

1) *output voltage is measured in no-load condition;*
2) *output current and available power are measured after 60 s of operation, with any over-current protective devices short-circuited, with a resistive load (including short-circuit) which produces the highest value of current and power respectively.*

Annex DD
(normative)

Flammability test for magnesium alloy fire ENCLOSURES or flame barriers (see 9.3.2)

DD.1 General

When magnesium alloy is used as a fire ENCLOSURE or a flame barrier, the flammability properties shall be determined to support the requirements of 9.3.2. The method described in Annex DD will demonstrate whether the material will ignite under typical conditions, and whether the flame, if it does ignite, will propagate long enough to cause a HAZARD of the spread of fire.

This method is similar to the method used for determining the flammability characteristics of plastics.

NOTE The test methods and conformance criteria of the 500 W vertical burning test for plastic materials of ANSI/UL 94 are equivalent.

Conformity is checked as specified in Clause DD.2 to Clause DD.5. During the test and until 1 min after the last application of the test flame, the sample shall not ignite.

DD.2 Samples

One sample is tested, consisting of a complete fire ENCLOSURE or flame barrier.

DD.3 Mounting of samples

The sample is mounted and oriented as it would be in actual use.

DD.4 Test flame

The 500 W nominal test flame of IEC 60695-11-3 shall be used.

DD.5 Test procedure

The test flame is applied to an inside surface of the sample at a minimum of three points and a maximum of five points, including the section of the sample where the material is the thinnest, sections of the sample where ventilation or other openings are located, and sections of the sample that are located near a source of ignition. If it is not possible to apply the flame to the inside surface, it may be applied to the outside surface.

If a vertical part is involved, the flame is applied at an angle of approximately 20° from the vertical. If ventilation or other openings are involved, the flame is applied to an edge of an opening, otherwise to a solid surface. In all cases, the tip of the inner blue cone of the flame shall be in contact with the sample.

The flame is applied to each point for 5 s, removed for 5 s, then reapplied again to the same point until a total of five applications have been made to this point. After that, the flame is removed for 60 s, and then applied in the same manner to the next test point on the sample.

Annex EE
(informative)

Information and documentation and correlation to their uses

Annex EE is not a certification requirement. It is included only to depict one of many examples of how industrial components are combined together to form a useful application. Other industries have a similar or the same workflow.

This example focuses on how information and documentation, regarding safety aspects, might flow through the development process of that useful application.

As shown in Figure EE.1, component products are generally combined together with other products to execute some useful application. As such, the information and documentation has more of an installer, service, system designer focus rather than an end use focus and need.

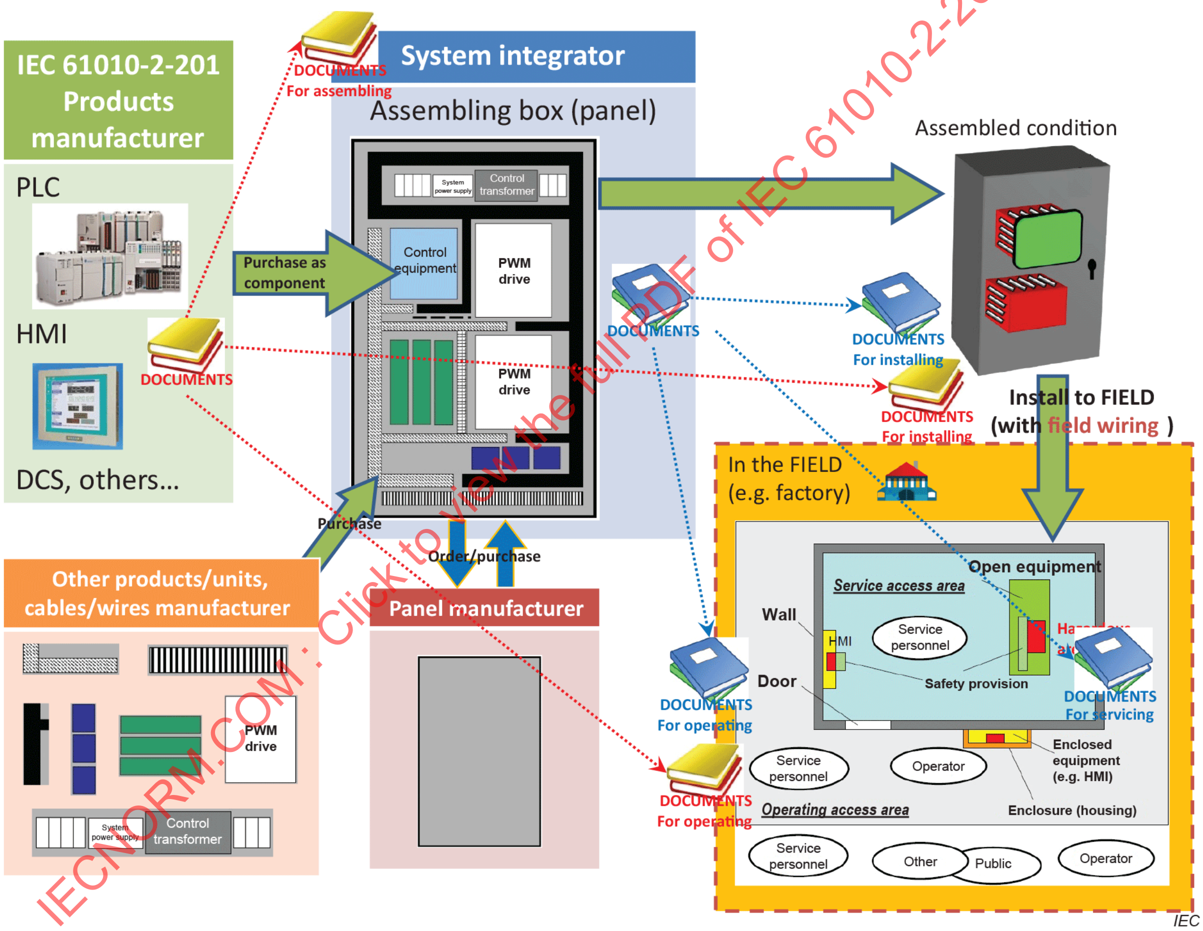


Figure EE.1 – Information and documentation for component products

Figure EE.2 shows an example of safety information as it is collected, selected and differentially compiled for different end uses, with regard to certain installations.

On the left are the documentation sets provided by the component manufacturers. These may include safety information (the focus in the example), programming information, specification information, end-of-life recycling information, warranty information, etc.

Moving to the right, those components may next be utilized by panel manufacturers to build their part of the overall installation. The panel manufacturers can select parts of the information from each of the component manufacturers to include in their safety information. The panel manufacturers can reformat, include and pass on this information along with their own panel safety information.

At the next stage, a system integrator selects, reformats, and passes on the relevant safety information which the system owner requested or the integrator feels the owner will require.

Lastly, the system owner may then again partition the information targeted to the OPERATORs and maintenance people.

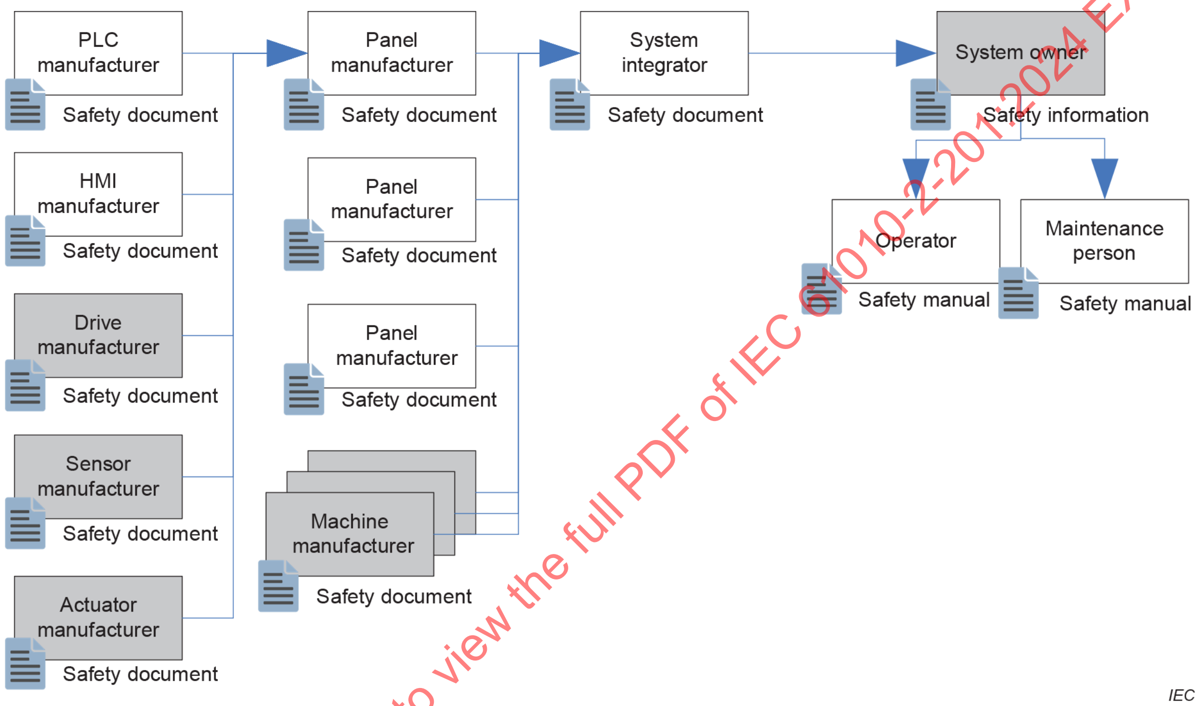


Figure EE.2 – Information and documentation accumulation and segregation tree for an example installation

This is one on many ways information and documentation of various types, threads its way from the manufacturer to the OPERATORs, maintenance personnel, etc.

Annex FF
(informative)

Measurement of CLEARANCES and CREEPAGE DISTANCES

The following examples complement those examples given in IEC 61010-1:2010, Annex C.

These examples are presented to enhance explanation of situations commonly found in control equipment. Very often they occur in the cases where surface mount devices (SMD) are utilized on printed wiring boards (PWBs). SMD devices present situations where there can be minimal or no distance between a component and the PWB. This brings into focus the question of which CLEARANCE and CREEPAGE rules apply with regard to the component of some material group (MG) and the PWB when the distance between component and PWB shrinks to minimal values.

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are indicated in the following Figure FF.1 and Figure FF.2. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

a) where the distance across a gap is equal to or larger than *X* (see Table FF.1), the CREEPAGE DISTANCE is measured along the contours of the body of the component (see Figure FF.1);
b) any recess is assumed to be bridged with an insulating link having a length equal to *X* and being placed in the least favourable position (see Figure FF.2);
c) CLEARANCES and CREEPAGE DISTANCES measured between parts which can assume different positions in relation to each other are measured when these parts are in their least favourable position.

In the following examples dimension *X* has the value given in Table FF.1 depending on the POLLUTION DEGREE.

Table FF.1 – Dimensions of *X*

POLLUTION DEGREE	Dimension *X* mm
1	0,25
2	1,0
3	1,5

If the associated CLEARANCE is less than 3 mm, the dimension *X* in Table FF.1 may be reduced to one-third of this CLEARANCE.

The MG of the various surfaces shall be taken into consideration.

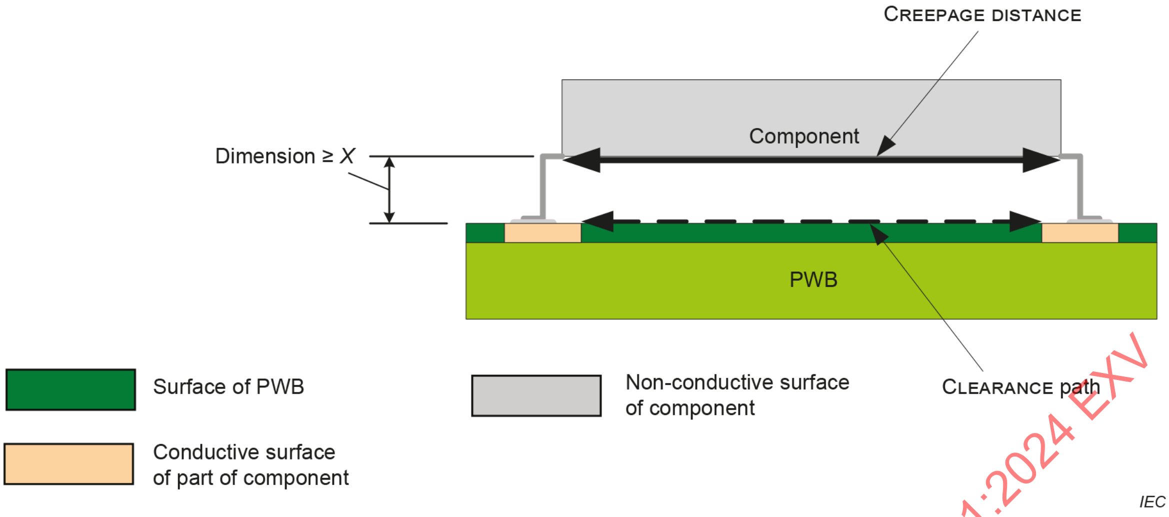


Figure FF.1 – Path of a component mounted to a PWB (side view)

EXAMPLE 1 Figure FF.1

The CLEARANCE is the shortest direct air path across the top of the PWB.

The CREEPAGE DISTANCE follows the contour of the component, along the shortest path measured on any side of the component.

NOTE 1 When components have a lower MG value than the surface on which they are mounted, the critical distance can be along the surface of the component. If the surface of the component and the surface on which it is mounted have the same MG, the critical CREEPAGE DISTANCE can be the direct path along the surface of the PWB.

NOTE 2 The conductive contacts on a component can be positioned such that the shortest path can be above or beside the component, and not necessarily below the component as shown.

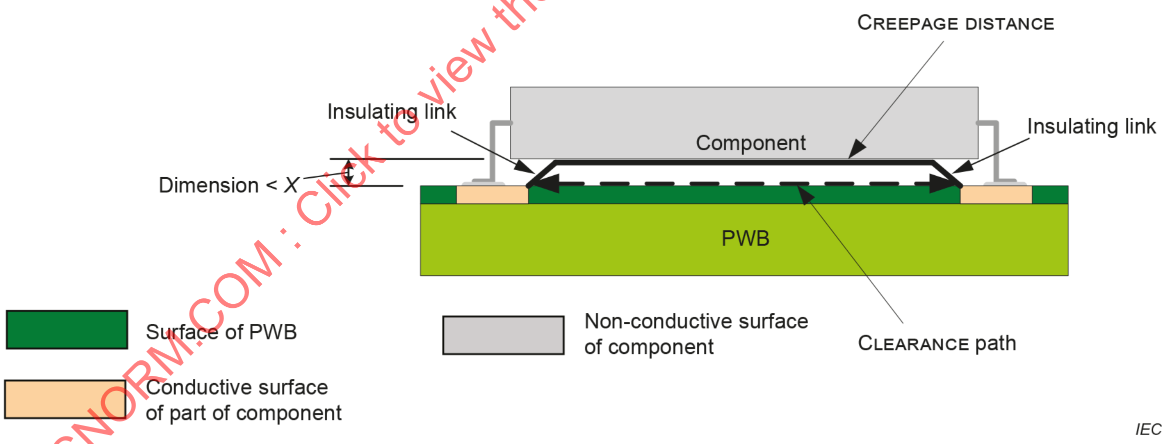


Figure FF.2 – Path of a component mounted to a PWB (side view)

EXAMPLE 2 Figure FF.2

The CLEARANCE is the shortest direct air path across the top of the PWB.

The CREEPAGE DISTANCE follows the insulating links to the contour of the bottom of the component.

NOTE 3 The measurement across the surface of the component starts where the link distance, value from Table FF.1, starting from the conductive contacts meets the surface of the component and continues to where the link distance from the opposite conductive contact meets the surface of the component.

NOTE 4 The conductive contacts on a component can be positioned such that the shortest path can be between these two contacts, or between one conductive contact and the conductive surface on the PWB, and not always between the two conductive surfaces on the PWB surface.

Bibliography

The Bibliography of IEC 61010-1:2010 and of IEC 61010-1:2010/AMD1:2016 applies except as follows:

Addition:

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses,* available at https://www.electropedia.org

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

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

IEC 60664-5, *Insulation coordination for equipment within low-voltage systems – Part 5: Comprehensive method for determining CLEARANCES and CREEPAGE distances equal to or less than 2 mm*[1]

IEC 60715, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60721-2-3, *Classification of environmental conditions – Part 2-3: Environmental conditions appearing in nature – Air pressure*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

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

IEC 61131 (all parts), *Programmable controllers*

IEC 61131-2:2017, *Industrial-process measurement and control – Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61131-6, *Programmable controllers – Part 6: Functional safety*

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61643 (all parts), *Low-voltage surge protective devices*

IEC 61643-21, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61643-311, *Components for low-voltage surge protective devices – Part 311: Performance requirements and test circuits for gas discharge tubes (GDT)*

[1] Withdrawn.

IEC 61643-321, *Components for low-voltage surge protective devices – Part 321: Specifications for avalanche breakdown diode (ABD)*

IEC 61643-331, *Components for low-voltage surge protection – Part 331: Performance requirements and test methods for metal oxide varistors (MOV)*

IEC 61800 (all parts), *Adjustable speed electrical power drive systems*

IEC 62133 (all parts), *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

IEC 62368 (all parts), *Audio/video, information and communication technology equipment*

UL 508:2018, *Standard for Industrial Control Equipment*

UL 1059, *Standard for Terminal Blocks*

UL 1642, *Standard for Lithium Batteries*

UL 2054, *Standard for Household and Commercial Batteries*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

EXIGENCES DE SÉCURITÉ POUR APPAREILS ÉLECTRIQUES DE MESURAGE, DE RÉGULATION ET DE LABORATOIRE –

Partie 2-201: Exigences particulières pour les équipements de commande

AVANT-PROPOS

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Cette troisième édition annule et remplace la deuxième édition parue en 2017. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) 1.1.1: clarification concernant les équipements inclus dans le domaine d'application;
b) 4.3.2.101: suppression du module à fibre optique;
c) 5.4.3: clarification de l'installation de l'équipement;
d) 6.7.1.1: révision de la figure représentant l'isolation entre des circuits séparés;
e) 6.7.101: suppression du paragraphe concernant l'isolation des BORNES A CABLER SUR PLACE de CATEGORIE DE SURTENSION II avec une tension nominale maximale de 1 000 V;
f) 6.7.1.101: ajout d'un nouveau paragraphe concernant l'isolation des CIRCUITS TBTS/TBTP;
g) 6.8.3: ajout d'une spécification pour le contrôleur de tension;
h) 6.9.3: ajout d'une exception supplémentaire pour le codage des couleurs;
i) 6.9.101: ajout d'un nouveau paragraphe concernant le câblage des circuits secondaires, par exemple TBTS/TBTP;
j) 8.2.2.101: ajout d'exigences supplémentaires pour les écrans en verre;
k) 8.3: suppression du paragraphe concernant l'essai de chute;
l) 9.3.2: ajout d'exigences supplémentaires pour les matériaux des connecteurs et les matériaux isolants;
m) clarification des exigences particulières relatives aux matériaux non métalliques;
n) Article 11: suppression des exigences particulières concernant la protection contre les DANGERS des fluides et des corps solides étrangers;
o) 12.4: ajout d'un paragraphe supplémentaire concernant le rayonnement hyperfréquence;
p) 14.102: clarification concernant la description des appareils de commutation.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
65/1049/FDIS	65/1095/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

La version française de la norme n’a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Une liste de toutes les parties de la série IEC 61010, publiées sous le titre général *Exigences de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire*, se trouve sur le site web de l'IEC.

Le présent document doit être utilisé conjointement avec l'IEC 61010-1:2010 et l'IEC 61010-1:2010/AMD1:2016.

Le présent document complète ou modifie les articles correspondants de l'IEC 61010-1, de façon à transformer cette publication en norme IEC: *Exigences particulières pour les équipements de commande.*

Lorsqu'un paragraphe particulier de l'IEC 61010-1 n'est pas mentionné dans le présent document, ce paragraphe s'applique pour autant que cela soit raisonnable. Lorsque le présent document mentionne "addition", "modification", "remplacement" ou "suppression", il convient d'adapter l'exigence, la spécification d'essai ou la note correspondante de l'IEC 61010-1 en conséquence.

Dans le présent document,

a) les caractères d'imprimerie suivants sont utilisés:
   - exigences et définitions: caractères romains;
   - NOTES: petits caractères romains;
   - *conformité et essais: caractères italiques*;
   - termes utilisés dans l'ensemble du présent document qui ont été définis à l'Article 3: PETITES MAJUSCULES EN CARACTERES ROMAINS.

b) les paragraphes, figures, tableaux et notes qui s'ajoutent à ceux de l'IEC 61010-1 sont numérotés à partir de 101. Les annexes qui sont ajoutées sont désignées AA et les éléments de liste supplémentaires sont désignés aa).

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture de ce document indique qu'il contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer ce document en utilisant une imprimante couleur.

INTRODUCTION

Les documents IEC 61010-2-2xx composent une série de normes relatives à la sécurité des appareils de mesure, de régulation et d'automatisation des processus industriels.

Le présent document spécifie l'ensemble des exigences et essais de sécurité relatifs aux équipements de commande (par exemple, automates programmables [PLC]), aux composants des systèmes à commande répartie (DCS), aux appareils d'E/S et à l'interface homme/machine (IHM).

Les termes de sécurité génériques sont définis dans l'IEC 61010-1. Les termes plus spécifiques sont définis dans chaque partie pertinente de la série IEC 61010.

EXIGENCES DE SÉCURITÉ POUR APPAREILS ÉLECTRIQUES DE MESURAGE, DE RÉGULATION ET DE LABORATOIRE –

Partie 2-201: Exigences particulières pour les équipements de commande

1 Domaine d'application et objet

L'Article 1 de l'IEC 61010-1:2010 et l'Article 1 de l'IEC 61010-1:2010/AMD1:2016 s'appliquent, avec les exceptions suivantes:

1.1.1 Appareils inclus dans le domaine d'application

Remplacement:

Remplacer le texte existant par ce qui suit:

La présente partie de l'IEC 61010 spécifie les exigences de sécurité et les essais de vérification associés pour les équipements de commande ou leurs périphériques associés, ou les deux.

Les équipements suivants en sont des exemples:

- les automates programmables (PLC, *Programmable Logic Controller*);
- les contrôleurs d'automatisation programmables (PAC, *Programmable Automation Controller*);
- les systèmes à commande répartie (DCS, *Distributed Control Systems*);
- les ordinateurs (PC) industriels et combinés PC-écran;
- les outils de programmation et de débogage (PADT, *Programming and Debugging Tools*);
- les affichages et les interfaces homme/machine (IHM);
- tout produit remplissant la fonction d'équipement de commande ou ses périphériques associés, ou les deux;
- les positionneurs; et
- les équipements de commande dont l'utilisation prévue consiste à contrôler et commander les machines, les processus industriels et de fabrication automatisés, par exemple par le biais d'un contrôle discret et continu.

Les composants des équipements susmentionnés et inclus dans le domaine d'application du présent document sont, par exemple:

- les alimentations autonomes (auxiliaires);
- les périphériques tels que les E/S numériques et analogiques;
- les E/S à distance;
- les équipements de réseau industriels, intégrés ou autonomes (par exemple, commutateurs, routeurs, stations de base sans fil).

Les équipements de commande et leurs périphériques associés sont conçus pour être utilisés dans un environnement industriel. Le présent document concerne les équipements conçus comme des EQUIPEMENTS OUVERTS ou des EQUIPEMENTS SOUS ENVELOPPE.

NOTE 1 Les équipements de commande également conçus pour être utilisés dans d'autres environnements ou à d'autres fins (par exemple, au sein de bâtiments pour commander l'éclairage ou d'autres installations électriques ou à bord de voitures, trains ou bateaux) peuvent faire l'objet d'exigences de conformité supplémentaires définies par la ou les normes de sécurité applicables à ces applications. Ces exigences peuvent concerner, par exemple, l'isolation, les espacements et les restrictions de puissance.

NOTE 2 Les calculateurs et équipements analogues inclus dans le domaine d'application de la série IEC 60950 ou de la série IEC 62368 et conformes à leurs exigences sont réputés être adaptés à une utilisation avec les équipements de commande inclus dans le domaine d'application du présent document. Cependant, certaines des exigences de la série IEC 60950 relative à la tenue à l'humidité et aux liquides sont moins strictes, le deuxième alinéa du 5.4.4 de l'IEC 61010-1:2010 tient compte de cet aspect.

Les équipements de commande couverts par le présent document sont généralement destinés à être utilisés dans des installations à basse tension de CATEGORIE DE SURTENSION II (IEC 60664-1), où la tension d'alimentation ASSIGNEE des équipements ne dépasse pas 1 000 V (valeur efficace) en courant alternatif (50/60 Hz) ou 1 000 V en courant continu.

Pour les équipements de commande destinés à être installés pour alimenter des systèmes de CATEGORIE DE SURTENSION III ou IV, des exigences supplémentaires sont indiquées à l'Annexe K.

Les exigences du Guide ISO/IEC 51 et du Guide IEC 104, en rapport avec la présente partie de l'IEC 61010, sont intégrées au présent document.

1.1.2 Appareils exclus du domaine d'application

Remplacement:

Remplacer le texte existant par ce qui suit:

Le présent document ne traite pas des aspects du système automatisé global, par exemple une chaîne de montage complète. Les équipements de commande (par exemple, DCS et PLC), leurs programmes d'application et leurs périphériques associés sont considérés comme des composants (les composants dans ce contexte sont des éléments qui n'accomplissent aucune fonction utile) d'un système automatisé global.

Étant donné que les équipements de commande (par exemple, DCS et PLC) sont des appareils de type composants, les considérations relatives à la sécurité du système automatisé global qui portent sur l'installation et l'application ne relèvent pas du domaine d'application du présent document. Se reporter à la série IEC 60364 ou aux réglementations nationales et locales applicables pour l'installation électrique et les lignes directrices.

1.2.1 Aspects inclus dans le domaine d'application

Remplacer la première phrase par ce qui suit:

L'objet des exigences du présent document est de s'assurer que tous les DANGERS pour l'OPERATEUR, le PERSONNEL D'ENTRETIEN et la zone environnante sont réduits à un niveau acceptable.

NOTE En utilisant les termes "OPERATEUR" et "PERSONNEL D'ENTRETIEN", le présent document prend en compte la perception des DANGERS en fonction de la formation et des compétences. Le Annexe AA fournit une approche générale à cet égard.

1.2.2 Aspects exclus du domaine d'application

Remplacement:

Remplacer le texte existant par ce qui suit:

Le présent document ne couvre pas:

a) la fiabilité, les fonctionnalités, les performances, ni les autres propriétés de l'équipement de commande qui ne sont pas liées à la sécurité;
b) les exigences mécaniques ou climatiques relatives à l'exploitation, au transport ou à l'entreposage;
c) les exigences relatives à la CEM (par exemple, la série IEC 61326 ou l'IEC 61131-2);
d) les mesures de protection relatives aux atmosphères explosives (par exemple, la série IEC 60079);
e) la sécurité fonctionnelle (par exemple, la série IEC 61508 ou l'IEC 61131-6).

2 Références normatives

L'Article 2 de l'IEC 61010-1:2010 et l'Article 2 de l'IEC 61010-1:2010/AMD1:2016 s'appliquent, avec les exceptions suivantes:

Addition:

Ajouter les nouvelles références suivantes:

IEC 60384-14, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: Spécification intermédiaire – Condensateurs fixes pour la suppression des interférences électromagnétiques et la connexion au réseau d'alimentation*

IEC 60695-2-11, *Essais relatifs aux risques du feu – Partie 2-11: Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis (GWEPT)*

IEC 60695-11-3, *Essais relatifs aux risques du feu – Partie 11-3: Flammes d'essai – Flamme de 500 W – Appareillage et méthodes d'essai de vérification*

IEC 60695-11-20, *Essais relatifs aux risques du feu – Partie 11-20: Flammes d'essai – Méthode d'essai à la flamme de 500 W*

IEC 60947-4-1, *Appareillage à basse tension – Partie 4-1: Contacteurs et démarreurs de moteurs – Contacteurs et démarreurs électromécaniques*

IEC 60947-4-2, *Appareillage à basse tension – Partie 4-2: Contacteurs et démarreurs de moteurs – Gradateurs, démarreurs et démarreurs progressifs à semiconducteurs de moteurs*

IEC 60947-5-1:2016, *Appareillage à basse tension – Partie 5-1: Appareils et éléments de commutation pour circuits de commande – Appareils électromécaniques pour circuits de commande*

IEC 61010-1:2010, *Règles de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire – Partie 1: Exigences générales*
IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030, *Exigences de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire – Partie 2-030: Exigences particulières pour les appareils équipés de circuits d'essai ou de mesure*

IEC 61810-1:2015, *Relais électromécaniques élémentaires – Partie 1: Exigences générales et de sécurité*

3 Termes et définitions

L'Article 3 de l'IEC 61010-1:2010 s'applique, avec les exceptions suivantes:

3.1.3
EQUIPEMENT PORTABLE

Modification:

Remplacer la définition par ce qui suit:

équipement conçu pour être tenu à la main et non maintenu en position fixe en UTILISATION NORMALE

3.2.3
BORNE DE TERRE DE PROTECTION

Modification:

La modification ne concerne que le texte anglais.

3.2.4
ENVELOPPE

Remplacement:

Remplacer la définition et la NOTE par ce qui suit:

enceinte assurant le type et le degré de protection approprié pour l'application prévue

[SOURCE: IEC 60050-151:2001, 151-13-08]

Ajouter les nouveaux termes et définitions suivants:

3.101
TEMPERATURE AMBIANTE
température, déterminée dans des conditions spécifiées, de l'air entourant l'équipement

3.102
EQUIPEMENT SOUS ENVELOPPE
équipement qui comporte une ENVELOPPE avec une fonction de sécurité ou une combinaison qui associe une ENVELOPPE avec une fonction de sécurité ainsi que des dispositifs d'installation qui recouvrent toutes ses faces latérales, à l'exception parfois de sa surface de montage, destiné à empêcher le personnel de toucher accidentellement des parties sous TENSION DANGEREUSE, des parties chaudes ou en mouvement à l'intérieur de l'équipement et qui satisfait aux exigences de rigidité mécanique, d'inflammabilité et de stabilité (le cas échéant)

EXEMPLE APPAREIL PORTATIF (A MAIN).

Note 1 à l'article: Cette définition est fondée sur l'IEC 60050-441:1984, 441-12-02.