

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Communication networks and systems for power utility automation –
Part 3: General requirements**

**Réseaux et systèmes de communication pour l'automatisation
des systèmes électriques –
Partie 3: Exigences générales**



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SYSTEMS FOR POWER UTILITY AUTOMATION –****Part 3: General requirements**

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International Standard IEC 61850-3 has been prepared by IEC technical committee 57: Power systems management and associated information exchange system.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

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

- a) requirements are in line with those of other equipment used in the same environment (e.g. protection relays);
- b) product safety added based on IEC 60255-27;
- c) EMC requirements completed and in line with IEC 60255 series and IEC 61000-6-5.

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

FDIS	Report on voting
57/1391/FDIS	57/1416/RVD

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

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

In this standard, the following print types are used:

- compliance statements: in italic type;
- markings: in bold type and caps.

A list of all parts in the IEC 61850 series, published under the general title *Communication networks and systems for power utility automation*, can be found on the IEC website.

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

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- withdrawn,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

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 3: General requirements

1 Scope

This part of IEC 61850 defines the general requirements, mainly regarding construction, design and environmental conditions for utility communication and automation IEDs and systems in power plant and substation environments. These general requirements are in line with requirements for IEDs used in similar environments, for example measuring relays and protection equipment.

When communication or automation IEDs are an integral part of another device in the power plant or substation, then the environmental requirements for the device itself apply to the communications equipment.

2 Normative references

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

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60255-21-1, *Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 1: Vibration tests (sinusoidal)*

IEC 60255-21-2, *Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 2: Shock and bump tests*

IEC 60255-21-3, *Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section 3: Seismic tests*

IEC 60255-27:2013, *Measuring relays and protection equipment – Part 27: Product safety requirements*

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

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

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

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

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

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

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2008, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2001, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-16:2002, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-4-17:2009, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*

IEC 61000-4-18:2006, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-4-29:2000, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

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

IEC 61180-1:1992, *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 61850 (all parts), *Communication networks and systems in substations*

IEC/TS 61850-2:2003, *Communication networks and systems in substations – Part 2: Glossary*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications*

CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 24:2010, *Information technology equipment – Immunity characteristics – Limits and methods of measurement*

ISO 780:1997, *Packaging – Pictorial marking for handling of goods*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols*. Available from <http://www.graphical-symbols.info/equipment>

ISO 9772, *Cellular plastics – Determination of horizontal burning characteristics of small specimens subjected to a small flame*

IEEE 1613:2009, *IEEE standard environmental and testing requirements for communications networking devices installed in electric power substations*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61850-2, as well as the following, apply.

3.1.1

accessible part

part which can be touched in normal operational use with a standard rigid or jointed test finger as specified in IEC 60529

Note 1 to entry: Accessible in normal operational use applies mainly to the front of the equipment only, for the purposes of this standard.

Note 2 to entry: A communication circuit/network, which may be connected and taken outside of the cubicle housing, the equipment, or on the front of the panel without the need to open a cover or flap to access it, should be considered to be accessible, i.e. should be PEB, PELV, SELV or equivalent.

[SOURCE: IEC 60050-442:1998, 442-01-15, modified — Notes 1 and 2 to entry have been added.]

3.1.2

adjacent circuits

electric circuits which are separated from the considered circuit by the necessary basic or double/reinforced insulation

Note 1 to entry: Circuits which are separated by far more than double or reinforced insulation are not considered to be adjacent.

[SOURCE: IEC 60255-27:2013, 3.2]

3.1.3

ambient air temperature

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

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

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

[SOURCE: IEC 60255-27:2013, 3.3]

3.1.4

automation

automation system

use of control systems and information technologies to reduce the need for human work in the production, transportation and distribution of energy

3.1.5

barrier

electrically protective barrier

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

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

[SOURCE: IEC 60050-826:2004, 826-12-23, modified — Note 1 to entry has been added.]

3.1.6

basic insulation

insulation of hazardous live parts which provides basic protection

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEC 60050-826:2004, 826-12-14]

3.1.7

bounding surface

outer surface of the equipment case, considered as though metal foil were pressed into contact with accessible surfaces of insulating material

[SOURCE: IEC 60255-27:2013, 3.6]

3.1.8

class I equipment

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

[SOURCE: IEC 60255-27:2013, 3.7]

3.1.9

class II equipment

equipment with

- basic insulation as provision for basic protection against electric shock, and
- supplementary insulation as provision for fault protection; or
- in which basic protection and fault protection are provided by reinforced insulation

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

[SOURCE: IEC 60255-27:2013, 3.8]

3.1.10

class III equipment

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

[SOURCE: IEC 60255-27:2013, 3.9]

3.1.11

clearance

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

[SOURCE: IEC 60255-27:2013, 3.10]

3.1.12

comparative tracking index

CTI

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

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

3.1.13

communication circuit

communication network

circuit/network for receiving and/or transmitting, digital or analogue signals

Note 1 to entry: It may communicate with other circuits via optical, magnetic or electromagnetic radiation means, or metallic connections.

[SOURCE: IEC 60255-27:2013, 3.12]

3.1.14

creepage distance

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

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

3.1.15

direct contact

electrical contact of persons with live parts

[SOURCE: IEC 60050-826:2004, 826-03-05, modified — "or animals" has been deleted.]

3.1.16

double insulation

insulation comprising both basic insulation and supplementary insulation

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

[SOURCE: IEC 60050-195:1998, 195-06-08, modified — Note 1 to entry has been added.]

3.1.17

ELV

extra low voltage

non-primary circuits complying with the following under normal operational conditions:

- not exceeding 33 V r.m.s. a.c. or 70 V d.c. i.e. ELV voltage limits, and
- separated from HLV by at least basic insulation

EXAMPLE 1 Non-primary circuits.

EXAMPLE 2 Analogue/digital inputs and outputs, complying with ELV voltage limits.

EXAMPLE 3 Connections to ELV terminations of other products.

Note 1 to entry: ELV circuits should not be accessible under normal operational conditions.

[SOURCE: IEC 60255-27:2013, Table A.1]

3.1.18

enclosure

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

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.1.19

equipment

single apparatus or set of devices or apparatuses, or a set of main devices of an installation, or all devices necessary to perform a specific task

Note 1 to entry: Examples of equipment are a power transformer, the equipment of a substation, measuring equipment.

Note 2 to entry: For the purpose of this standard, equipment is utility communication and automation equipment.

[SOURCE: IEC 60050-151:2001, 151-11-25, modified — Note 2 to entry has been added.]

3.1.20

equipment under test

EUT

equipment submitted to a test, including any accessories, unless otherwise specified

3.1.21

exposed conductive part

conductive part of electrical equipment, which is accessible and which is not normally live, but which may become live under a single-fault condition

Note 1 to entry: For equipment which is not enclosed, the frame, the fixing devices, etc., may form the exposed conductive parts.

Note 2 to entry: For equipment which is enclosed, the conductive parts which are accessible when the equipment is mounted in its normal position of use, including those of its fixing surface, form the exposed conductive parts.

[SOURCE: IEC 60050-826:2004, 826-12-10, modified — Notes 1 and 2 to entry have been added.]

3.1.22**fire enclosure**

part of the equipment intended to minimize the spread of fire or flames from within

[SOURCE: IEC 60255-27:2013, 3.19]

3.1.23**functional earthing****functional grounding**, en US

earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety

[SOURCE: IEC 60050-195, Amendment 1:2001, 195-01-13]

3.1.24**functional insulation**

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

[SOURCE: IEC 60050-195:1998, 195-02-41]

3.1.25**hazardous energy level**

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

[SOURCE: IEC 60255-27:2013, 3.22]

3.1.26**hazardous live part**

live part at a voltage exceeding 33 V a.c. or 70 V d.c.

[SOURCE: IEC 60050-826:2004, 826-12-13, modified — The voltage values have been provided.]

3.1.27**HLV****hazardous live voltage**

normal operational condition voltage which exceeds 33 V a.c. or 70 V d.c.

[SOURCE: IEC 60255-27:2013, 3.23]

3.1.28**HBF class foamed material**

foamed material tested in the thinnest significant thickness used and classified HBF according to ISO 9772

[SOURCE: IEC 60255-27:2005, 3.27]

3.1.29**HB40 class material**

material tested in the thinnest significant thickness used and classified HB40 according to IEC 60695-11-10

[SOURCE: IEC 60255-27:2013, 3.25]

3.1.30

HB75 class material

material tested in the thinnest significant thickness used and classified HB75 according to IEC 60695-11-10

[SOURCE: IEC 60255-27:2013, 3.26]

3.1.31

high-integrity

high-integrity part or component is considered not to become defective in such a manner as to cause a risk of hazard within the sense of this standard

Note 1 to entry: A high-integrity part or component is considered as not subject to failure when a single-fault condition is applied.

[SOURCE: IEC 60255-27:2013, 3.27]

3.1.32

limited-energy circuit

circuit that meets all the criteria given in 7.12 of IEC 60255-27:2013

[SOURCE: IEC 60255-27:2013, 3.28]

3.1.33

live part

conductor or conductive part intended to be energized in normal operational use, including a neutral conductor

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19, modified — "but by convention not a PEN conductor or PEM conductor or PEL conductor" has been deleted.]

3.1.34

micro-environment

ambient conditions which immediately surround the clearance and creepage distance under consideration excluding self-produced pollution resulting from normal operation of the accessory

Note 1 to entry: The micro-environment of the creepage distance or clearance and not the environment of the equipment determines the effect on the insulation.

[IEC 60050-442:1998, 442-01-29, modified — Note 1 to entry has been modified.]

3.1.35

non-primary circuit

circuit electrically isolated from the a.c. or d.c. supply and from external VTs and CTs

[SOURCE: IEC 60255-27:2013, 3.32]

3.1.36

normal operational use

equipment installed and operated under normal operational conditions, with all covers and protective measures in place

[SOURCE: IEC 60255-27:2013, 3.33]

3.1.37**overvoltage category**

number defining a transient overvoltage condition

Note 1 to entry: Overvoltage categories I, II, III are used.

Note 2 to entry: See Clause A.1 of IEC 60255-27:2013 for overvoltage category details.

[SOURCE: IEC 60255-27:2013, 3.35]

3.1.38**PEB circuit****protective equipotential bonding circuit**

non-primary circuits complying with ELV voltage limits and the following conditions:

- basic protection against electric shock is provided by basic insulation separating HLV from PEB circuits; and
- for fault protection, PEB circuits and accessible conductive parts, shall be bonded to the protective conductor terminal and shall comply with clause 6.6.5, which will prevent hazardous live voltages in PEB circuits

EXAMPLE 1 Analogue/digital inputs and outputs which may be connected direct to communication networks or circuits.

EXAMPLE 2 PEB ports which are suitable for connection to PEB ports of other products.

Note 1 to entry: See IEC 60255-27:2013, Figure A.3.

Note 2 to entry: PEB circuits may be accessible and are safe to touch under both normal operational and single-fault conditions.

Note 3 to entry: PEB circuits may be considered as protective earthed circuits or earthed accessible parts for the purposes of IEC 60255-27:2013, Table A.2.

3.1.39**PELV circuit****protective extra low voltage circuit**

non-primary circuits complying with ELV voltage limits and the following conditions:

- PELV circuits shall be separated from HLV by reinforced/double insulation; and
- PELV circuits may be connected to functional earth, the protective (earth) conductor, or have provision for an earth connection

EXAMPLE 1 Analogue/digital inputs and outputs which may be connected directly to communication networks or circuits.

EXAMPLE 2 PELV ports which are suitable for connection to PELV ports of other products.

Note 1 to entry: See IEC 60255-27:2013, Figure A.2.

Note 2 to entry: PELV circuits may be accessible and are safe to touch under both normal operational and single-fault conditions.

3.1.40**pollution**

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

Note 1 to entry: Ionized gases of a temporary nature are not considered to be a pollution.

[SOURCE: IEC 60050-442:1998, 442-01-28]

3.1.41**pollution degree**

number characterizing the expected pollution of the micro-environment

[SOURCE: IEC 60255-27:2013, 3.39]

3.1.42

pollution degree 1

normally no pollution or only dry, non-conductive pollution occurs. The pollution has no influence

[SOURCE: IEC 60255-27:2013, 3.40]

3.1.43

pollution degree 2

normally only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected

[SOURCE: IEC 60255-27:2013, 3.41]

3.1.44

pollution degree 3

normally conductive pollution, or dry non-conductive pollution occurs, which becomes conductive, due to condensation which is to be expected

[SOURCE: IEC 60255-27:2013, 3.42]

3.1.45

pollution degree 4

normally the pollution generates persistent conductivity caused by conductive dust or by rain or snow

[SOURCE: IEC 60255-27:2013, 3.43]

3.1.46

primary circuit

circuit connected direct to the a.c. or d.c. supply input. Equipment circuits connected to VTs or CTs are also classed as primary circuits

Note 1 to entry: See IEC 60255-27:2013, Annex B.

Note 2 to entry: Measuring relay circuits supplied from an external a.c. or d.c. power supply, complying with ELV circuit requirements, as in IEC 60255-27:2013, Table A.1, may be treated as non-primary circuits, providing that any transients or impulse voltages on the supply output do not exceed the requirements of Figure 2 of IEC 61010-1:2010.

[SOURCE: IEC 60255-27:2013, 3.44]

3.1.47

product family

range of products based on a common hardware and/or software platform

[SOURCE: IEC 60255-1:2009, 3.17]

3.1.48

protective bonding

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

[SOURCE: IEC 60255-27:2013, 3.45]

3.1.49**protective bonding resistance**

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

[SOURCE: IEC 60255-27:2013, 3.46]

3.1.50**protective conductor**

conductor provided for purposes of safety, for example, protection against electric shock, by electrically connecting any of the following parts:

- main earthing terminal;
- exposed conductive parts;
- earth electrode;
- earthed point of the source or artificial neutral

[SOURCE: IEC 60050-195:1998, 195-02-09, modified — "by electrically connecting any of the following parts: main earthing terminal, accessible conductive parts, earth electrode, earthed point of the source or artificial neutral" has been added.]

3.1.51**protective earthing****protective grounding**, en US

earthing of a point in equipment for protection against electric shock in case of a fault

[SOURCE: IEC 60255-27:2013, 3.48]

3.1.52**protective impedance**

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

Note 1 to entry: A protective impedance should withstand the dielectric voltage withstand test for double insulation, and its choice should take account of its predominated failure mode.

[SOURCE: IEC 60050-442:1998, 442-04-24, modified — the term "electronic switch" has been replaced by "equipment" and Note 1 to entry has been added.]

3.1.53**protective screening****protective shielding**, en US

separation of electric circuits and/or conductors from hazardous live parts by an electrically protective screen connected to the protective equipotential bonding system and intended to provide protection against electric shock

[SOURCE: IEC 60050-195, Amendment 1:2001, 195-06-18]

3.1.54**protective separation**

separation of one electric circuit from another by means of

- double insulation, or
- basic insulation and electrically protective screening, or
- reinforced insulation

[SOURCE: IEC 60255-27:2013, 3.51]

3.1.55

rated impulse voltage

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

[SOURCE: IEC 60255-27:2013, 3.52]

3.1.56

rated insulation voltage

RIV

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

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

Note 2 to entry: The rated insulation voltage refers to the insulation between electric circuits.

Note 3 to entry: For clearances and solid insulation the peak value of the voltage occurring across the insulation or clearance is the determining value for the rated insulation voltage. For creepage distances, the r.m.s. or d.c. value is the determining value.

[SOURCE: IEC 60255-27:2013, 3.53]

3.1.57

rated voltage

value of voltage assigned by the manufacturer, for a specified operating condition of a component, device or equipment

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

[SOURCE: IEC 60255-27:2013, 3.54]

3.1.58

reinforced insulation

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

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

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

3.1.59

restricted access area

area accessible only to electrically skilled persons and electrically instructed persons with the proper authorization and knowledge of any safety hazards

Note 1 to entry: These areas include closed switch plants, distribution plants, switchgear cells, transformer cells, distribution systems in metal-sheet enclosures or in other closed installations.

[SOURCE: IEC 60050-195:1998, 195-04-04, modified — "and knowledge of any safety hazards" and Note 1 to entry have been added.]

3.1.60

routine test

conformity test made on each individual item during or after manufacture

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

3.1.61

screen

shield, en US

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

[SOURCE: IEC 60255-27:2013, 3.59]

3.1.62

SELV circuit

separated/safety extra low voltage circuit

non-primary circuits complying with ELV voltage limits and the following conditions:

- separated from HLV by reinforced/double insulation, and
- there shall be no provision for an earth connection

EXAMPLE 1 Analogue/digital inputs and outputs which may be connected direct to unearthed communication networks or circuits.

EXAMPLE 2 SELV ports which are suitable for connection to SELV ports of other products.

Note 1 to entry: See IEC 60255-27:2013, Figure A.1.

Note 2 to entry: SELV circuits may be accessible and are safe to touch under both normal operational and single-fault conditions.

Note 3 to entry: Connection of an earth to a SELV circuit is not permitted; for example, connection to an earthed cable screen or earthed communication circuit is not permitted. Where this is required, the circuit definition should change in accordance with IEC 60255-27:2013, Figure A.2 (PELV).

3.1.63

supplementary insulation

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

[SOURCE: IEC 60050-195:1998, 195-06-07, modified — "for fault protection" has been replaced by "in order to provide protection against electric shock in the event of a failure of basic insulation".]

3.1.64

tracking

progressive degradation of the surface of a solid insulating material by local discharges to form conducting or partially conducting paths

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

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

3.1.65

type test

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

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

3.1.66

user

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

[SOURCE: IEC 60255-27:2013, 3.65]

**3.1.67
withstand**

state of survival of the equipment to the related imposed environmental or test condition (for example, impulse voltage)

[SOURCE: IEC 60255-27:2013, 3.66]

**3.1.68
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 to entry: Transients are disregarded.

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

[SOURCE: IEC 60255-27:2013, 3.67]

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

a.c.	alternating current
AIS	air insulated switchgear
d.c.	direct current
GIS	gas insulated switchgear
HMI	human – machine interface
IED	intelligent electronic device
IP	inter-networking protocol
MTTF	mean time to failure
SCADA	supervisory control and data acquisition
SF6	sulphur hexafluoride
TCP	transport control protocol

4 Environmental conditions

4.1 General

Clause 4 specifies environmental conditions for weather-protected equipment during stationary use, maintenance and repair.

Where equipment forms an integral part with high voltage switchgear and controlgear (for example components of the process bus), IEC 62271-1 shall apply.

4.2 Normal environmental conditions

Utility communication and automation IEDs and systems in power plant and substation environments are intended to be used in the normal service conditions listed in Table 1.

Table 1 – Normal environmental conditions

Environmental parameters		Conditions
Ambient temperature ^a	Upper limit	≤ +55 °C
	Lower limit	≥ –10 °C ^d
Solar radiation		Negligible
Altitude		≤ 2 000 m
Air pollution by dust, salt, smoke, corrosive/flammable gas, vapours		No significant air pollution ^c
Relative humidity: 24 h average		From 5 % to 95 % ^b
Vibration, earth tremors		According to IEC 60255-21 series class environment class 0 or class 1
Electromagnetic disturbances		Electromagnetic environment defined by usage location
^a The ambient air temperature is the maximum or minimum temperature around the enclosure of the IED. Depending on the type of climate and the type of weather-protected location where an IED is mounted, temperature limits may be more or less severe. Consequently, the equipment should be capable of operating under one of the preferred standard temperature ranges listed in 5.5. ^b These conditions correspond to maximum values given for classes 3C1 and 3S1 in IEC 60721-3-3. ^c No condensation or ice is considered. ^d Display may become dark or un-readable at low temperature; however, this condition does not affect the proper operation of the protection or other functions.		

4.3 Special environmental conditions

When equipment is used under conditions different from the normal environmental conditions given in Table 1, the user shall refer to Table 2. In this case, there shall be an agreement between the manufacturer and the user.

Table 2 – Special environmental conditions

Environmental parameters		Conditions
Ambient temperature ^a	Upper limit	> +55 °C
	Lower limit	< –10 °C ^f
Altitude		> 2 000 m ^b
Air pollution by dust, salt, smoke, corrosive/flammable gas, vapours		No significant air pollution ^c
Relative humidity: 24 h average		> 95 % ^d
Vibration, earth tremors		According to IEC 60255-21 series class environment class 2 ^e
Electromagnetic disturbances		Electromagnetic environment defined by usage location
^a The ambient air temperature is the maximum or minimum temperature around the enclosure of the IED. ^b For altitudes higher than 2 000 m users shall refer to IEC 60664-1. ^c These conditions correspond to maximum values given for classes 3C2 and 3S2 in IEC 60721-3-3. ^d In Tropical indoor conditions, the average value of relative humidity measured during a period of 24 h can be 98 %. ^e This severity class concerns measuring relays and protection equipment for which a very high margin of security in service is required, or where the seismic shock level is very high. ^f Display may become dark or un-readable at low temperature; however, this condition does not affect the proper operation of the protection or other functions.		

4.4 Storage conditions

Utility communication and automation IEDs are intended to be stored in their supplied packaging. The temperature range of storage shall be chosen from the ranges given in 5.5 and stated by the manufacturer.

5 Ratings

5.1 General

The rated values listed below are preferred values for specification purposes. Other values may be adopted according to conditions of operation and use.

5.2 Rated voltage – Auxiliary energizing voltage

5.2.1 AC voltage

The preferred rated values of a.c. voltages, in r.m.s value, are given below, together with those values multiplied by 3 or 1/3:

100 V; 110 V; 115 V; 120 V; 200 V; 230 V.

5.2.2 DC voltage

The preferred rated values of d.c. voltages are given below:

12 V; 24 V; 48 V; 60 V; 110 V; 125 V; 220 V; 250 V.

5.2.3 Operating range

The preferred operating range is 80 % to 110 % of the rated voltage.

5.3 Binary input and output

5.3.1 Binary input

The manufacturer shall declare the ratings.

5.3.2 Binary output

The manufacturer shall declare the ratings.

5.4 Rated burden

The burden for the power supply (a.c. including power factor/d.c.) at quiescent state and maximum load.

The maximum start-up inrush current of the power supply circuits shall also be stated.

5.5 Rated ambient temperature

Unless otherwise stated, the preferred rated ambient temperature is –10 °C to +55 °C for the operation of the equipment. Other recommended values are:

–5 °C to +40 °C	0 °C to +40 °C	0 °C to +45 °C	–10 °C to +50 °C
–25 °C to +40 °C	–20 °C to +55 °C	25 °C to +55 °C	–20 °C to +60 °C
–20 °C to +70 °C	–25 °C to +70 °C	–30 °C to +65 °C	–40 °C to +70 °C

6 Design and construction

6.1 Marking

6.1.1 General

When mounted in its normal operating position, the equipment should carry, where possible, markings in accordance with 6.1.2 to 6.2 inclusive. These markings shall, where possible, be visible from the exterior of the equipment or be visible by removing a cover or the opening of an aperture without the aid of a tool, if the cover or aperture is intended to be removed by the user.

Where, because of space limitations, it is not possible for these markings to be visible in the normal operating position or be elsewhere on the equipment, an explanation of these symbols shall be included in the equipment documentation (see Table 3 for the description of the symbols).

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

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

The markings listed in Clause 6 shall be considered to be safety-related.

SAFETY MARKING SHALL WHEREVER POSSIBLE TAKE PRECEDENCE OVER ANY FUNCTIONAL MARKINGS.

6.1.2 Identification

The equipment shall, as a minimum, be marked with

- the name or trade mark of the manufacturer or supplier;
- the model or type reference;
- If, equipment bearing the same distinctive designation (model number) is manufactured at more than one location, the manufacturing location.

The marking of factory location can be in code.

The above are the minimum mandatory requirements that shall be marked on the equipment.

Compliance with 6.1.1 and 6.1.2 shall be checked by inspection.

6.1.3 Auxiliary supplies, I/O

6.1.3.1 General requirements for marking

For marking the following should be taken into account:

- a.c. – with symbol 2 of Table 3 and rated frequency or frequency range;
- d.c. – with symbol 1 of Table 3;
- symbol 3 of Table 3 on equipment for a.c. and d.c. supply;
- a hyphen (-) shall be used to separate the lower and upper nominal voltages, for example, 125 V-230 V;
- the burden in watts (active power) or volt-amperes (apparent power) or the rated input current, with all accessories or plug-in modules connected.

The documentation shall specify the burden of individual digital inputs, output relays and other I/O ports of significant burden in order for the user to calculate the worst-case burden for the equipment application.

The values shall be measured with the equipment powered at nominal voltage, but not be operational.

The measured value shall not exceed the marked value by more than 10 %;

- the rated supply voltage(s) or the rated supply voltage range.
- if the equipment can be used on more than one voltage range then the separate voltage ranges shall be marked unless their maximum and minimum values do not differ by more than 20 % of the mean value.

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

6.1.3.2 Auxiliary supply

The following information shall be provided on the equipment and in the documentation:

- a.c. and/or d.c. supply;
- the rated values.
- in the documentation:
- the burden.

6.1.3.3 Inputs

The following information shall be provided in the documentation:

- a.c. and/or d.c. supply;
- the rated values;
- burden on the supply input.

6.1.3.4 Outputs

The following information shall be provided in the documentation:

- the kind of output, for example, relay, optocoupler etc;
- burden on the supply input;
- the switching capability on/off;
- the switching voltage;
- the permissible current, continuous value and short time value for 1 s;
- withstand voltage across open contacts.

Compliance with 6.1.3.1 to 6.1.3.4 is checked by inspection or by measurement.

6.1.4 Fuses

Where a replaceable equipment fuse is used, the fuse rating and type (for example, the indication of rupturing speed) shall be marked adjacent to the fuse and details provided in the user manual. If the fuse is soldered into the printed circuit board, or there is not sufficient space on the board, then fusing details may be provided in the user manual only.

Rupturing speed codes of IEC 60127-1 should be used, as follows:

- very quick-acting: FF or black;

- quick-acting: F or red;
- medium time lag: M or yellow;
- time lag: T or blue;
- long time lag: TT or grey.

Equipment fuses which are not replaceable by the user shall have the same information as above, which shall be provided in the equipment documentation.

The recommended ratings of protective fuses or other external protective devices necessary to ensure that the equipment is safe under single-fault conditions shall be detailed in the equipment installation and technical documentation.

Compliance with 6.1.4 shall be checked by inspection.

6.1.5 Terminals and operating devices

Where necessary for safety, an indication using words, numbers or symbols shall be given of the purpose of all terminals, connectors, controls and indicators, including any operating sequences. Where there is insufficient space, it is permissible to use symbol 14 of Table 3. In such cases, the relevant information shall be provided in the equipment documentation.

AC or d.c. supply input connection terminals shall be identifiable.

Other terminals and operating devices shall be marked as follows: markings should be adjacent to or on the terminal but preferably should not be on a part, which can be removed without the aid of a tool.

- Functional earth terminals with symbol 5 of Table 3.
- Protective conductor terminals with symbol 6 of Table 3.

If the protective conductor terminal is part of a component (for example, terminal block) or subassembly and there is insufficient space, then it may be marked with symbol 5 of Table 3.

Marking should not be indicated on easily changeable fixtures such as screws. Where the power and earth connections are provided by a plug/socket device, there is no requirement to mark the earth connection adjacent to such a device.

Circuit terminals designed to be accessible, floating at a voltage which is not hazardous live, are permitted to be connected to a common functional earth terminal or system (for example, a co-axial screening system). This terminal shall be marked with symbol 7 of Table 3, if this connection is not self-evident.

If the equipment contains lasers or high-intensity infra-red diodes of Class 2 rating or higher, and the output of these can be viewed under normal operational use or maintenance conditions, then the equipment shall be marked in accordance with IEC 60825-1.

Compliance with 6.1.5 shall be checked by inspection.

6.1.6 Equipment protected by double or reinforced insulation

Equipment protected throughout by double or reinforced insulation shall be marked with symbol 11 of Table 3, unless this equipment is provided with a protective conductor terminal or if a functional earth/ground connection (for example, via cable screen) can be made to the equipment, in normal operational use.

Equipment which is only partially protected by double or reinforced insulation shall not bear symbol 11 of Table 3.

NOTE Basic insulation is acceptable in the terminal area of insulation Class II equipment if it is accessed only under maintenance conditions.

Compliance with 6.1.6 shall be checked by inspection.

6.1.7 Batteries

6.1.7.1 Replaceable batteries

If the equipment has replaceable batteries and the replacement of these by an incorrect type of battery could result in an explosion (for example, in the case of certain types of Lithium batteries) then,

- if a user can access the battery, there shall be a marking close to the battery or a statement in both the operating instructions and servicing instructions;
- if the battery is elsewhere in the equipment, marking is required; this shall be close to the battery or in a statement included in the servicing instructions.

The marking or statement shall be similar to the following:

CAUTION – Risk of fire if battery is replaced with incorrect type or polarity. Dispose of used batteries according to instructions.

It is permissible, where space is limited on the equipment, to use symbol 14 of Table 3.

The polarity of the battery shall be marked on the equipment unless it is not possible to insert the battery with incorrect polarity.

6.1.7.2 Charging

Equipment which has facilities for the re-charging of internal batteries where non-rechargeable cells could be fitted and connected in the battery compartment shall be marked in or near to this compartment, warning against the charging of non-rechargeable batteries. This warning shall also indicate the type of rechargeable battery that shall be used within the recharging circuit.

Where space does not permit, this information shall be provided in the equipment documentation. In such cases, it is preferred that symbol 14 of Table 3 be adjacent to the battery.

Compliance with 6.1.7.1 and 6.1.7.2 is checked by inspection.

Table 3 – Symbols

Number	Symbol	Publication	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

Number	Symbol	Publication	Description
6		IEC 60417- 5019 (2006-08)	Protective conductor terminal
7		IEC 60417-5020 (2002-10)	Frame or chassis terminal
8		IEC 60417- 5021 (2002-10)	Equipotentiality
9A		IEC 60417- 5007 (2002-10)	On (Supply)
9B		IEC 60417- 5008 (2002-10)	Off (Supply)
10		IEC 60417- 5010 (2002-10)	On/Off (Supply)
11		IEC 60417- 5172 (2003-02)	Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 61140)
12		IEC 60417- 5036 (2002-10)	Caution, risk of electric shock
13		IEC 60417- 5041 (2002-10)	Caution, hot surface
14		ISO 7000-0434 (2004-01)	Caution, refer to documentation
15		ISO 7000-017(2004-01)	230/110 V AUTO or 230/110 V
[SOURCE: IEC 60255-27:2013, Table 10] NOTE 1 IEC 60417-1 should be referred to for warning symbol dimensions. NOTE 2 Colour requirements for symbols 12, 13 and 14 do not apply to markings on equipment provided that the symbol is moulded or engraved to a depth or raised height of 0,5 mm or that the symbol and outline are contrasting in colour with the background.			

6.1.8 Test voltage marking

The symbols indicated in Table 4 shall be used for marking of the test voltage(s) if the manufacturer chooses to mark the equipment.

Table 4 – Symbols and marking of test voltage(s)

Dielectric test voltage	Symbol
Test voltage 500 V	
Test voltage above 500 V (for example, 2 kV)	
Impulse test voltage	Symbol
Test voltage 1 kV	
Test voltage 5 kV	
[SOURCE: IEC 60255-27:2013, Table 11]	

6.1.9 Warning markings

In general, for rack- or panel-mounted equipment, markings are permitted on any surface that becomes visible after removal of the equipment from the rack or panel.

This is also applicable to the rear plate of rack- or panel-mounted equipment where there is insufficient space for warning markings. Symbols 14 and/or 12 of Table 3 shall be used in this case, as close as possible to the rear plate.

Where access in normal operational use presents a risk of electric shock, symbol 12 of Table 3 warning marking shall be used; this shall be visible either from the front panel or be visible after removing a cover or opening a door or flap without the aid of a tool.

If the user needs to refer to equipment documentation or instruction literature then the equipment shall be marked with symbol 14 of Table 3.

If the equipment documentation states that the user is permitted access, using a tool, to any part which in normal operational use may be hazardous live, the equipment shall carry a warning stating that the equipment shall be isolated or disconnected from hazardous live voltage before access is affected.

The size of warning markings shall be as follows:

- 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;
- 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.

For battery requirements, see 6.1.8.

Markings should not be on the bottom of the equipment, except on hand-held equipment or where space is limited.

Compliance with 6.1.8 and 6.1.9 shall be checked by inspection.

6.1.10 Marking durability

All markings shall remain clear and legible under conditions of normal operational use and shall resist the effects of cleaning agents as specified by the manufacturer. This shall also include the effect of natural or artificial light.

An adhesive that is permanent shall be used to secure adhesive labels.

After compliance testing these labels shall not have become loose nor shall the edges and corners curl.

Compliance shall be checked by inspection and by rubbing, by hand, without undue pressure:

- for 15 s with a cloth soaked with a cleaning agent(s) as specified by the manufacturer;
- if no agent is specified then with water.

6.2 Documentation

6.2.1 General

The equipment documentation shall clearly identify the equipment and include the name and address of the manufacturer or its agent. Information for safety shall be delivered with the equipment.

The manufacturer shall provide, on request, documentation that includes the technical specification, instructions for commissioning and for the use of the equipment. Where relevant, the documentation shall cover any calibration, maintenance and subsequent safe disposal and decommissioning of the equipment and any of its replaceable parts.

Manufacturers shall supply, on request, documentation relating to equipment type tests and routine testing.

Where applicable, warning statements and a clear explanation of warning symbols marked on the equipment shall be included in the documentation. In particular, wherever Symbol 14 of Table 3 is used, there shall be a statement to the effect that the documentation shall be consulted to establish the nature of any potential hazard and any actions which need to be taken to eliminate or minimize this hazard.

The documentation shall include the following:

- a statement that the user shall be responsible for ensuring the integrity of any protective conductor connections before carrying out any other actions;
- a statement that the user shall also be responsible for checking equipment ratings, operating instructions and installation instructions before commissioning or maintenance;
- the information specified in 6.2.2 to 6.2.5;
- the intended use of the equipment.

6.2.2 Equipment ratings

6.2.2.1 General

The equipment documentation shall include the following:

- the installation category (overvoltage category) for which the equipment is intended (this is related to the ability of the equipment to withstand transient overvoltages);
- the supply voltage or voltage range, frequency or frequency range and power or current rating of the equipment;
- the permitted fluctuation from the nominal functional value should also be stated, for example, the lower and upper functional voltages;
- a description of all input and output connections.

6.2.2.2 Fuses and external protective devices

The type, current rating and voltage rating of any internal fuse shall be stated according to 6.1.4. This shall include fuses that may or may not be accessed by a user for replacement.

The recommended fuse type or other protective means shall take into account the switching capacity and interrupting speed.

The type, current rating and voltage rating of any external fuse or protective device required for safe operation of the equipment shall be given in the product documentation.

Where it is recommended that an external switch, circuit breaker or other protective device be connected near to the equipment, this shall be stated.

6.2.2.3 Environmental requirement

The equipment documentation shall state the following:

- the IP rating at the front of the equipment when it is mounted in its normal position of use;
- the pollution degree for the equipment for example, pollution degree 2 when mounted in its normal position of use.

The insulation class of the equipment for example, Class I equipment when mounted in its normal position of use.

Compliance with 6.2.1 to 6.2.2.2 is checked by inspection.

6.2.3 Equipment installation

For installation purposes the equipment documentation shall include, as appropriate:

- instructions relating to the safe mounting of the equipment including any specific location and assembly requirements;
- instructions relating to the protective earthing of the equipment. This shall include a recommendation of the size of wire to be used and a statement indicating that protective earth connections should not be removed when the equipment is energized;
- any special ventilation requirements shall be stated. This is related to the heat dissipated by the equipment;
- the manufacturer shall also indicate the maximum number or percentage of digital input circuits and output relays, which may be energized simultaneously at the maximum ambient temperature;
- wire type, size and rating necessary for correct installation of the equipment;
- information regarding the requirement for and the specification of any external devices required for the safe operation of the equipment, as in 6.2.2.1.

Compliance with 6.2.3 is checked by inspection.

6.2.4 Equipment commissioning and maintenance

Equipment instructions given to the user concerning preventative maintenance and inspection shall be given in sufficient detail to ensure the safety of these procedures. Instructions shall include recommendations relating to safety earthing and de-energization of the equipment, where applicable.

The following shall also be included, where applicable.

- Instructions for fault-finding and repair, where applicable to a user, shall be given to the extent that is relevant for operation and maintenance.
- The manufacturer shall specify any parts, which shall only be examined or supplied by the manufacturer or his agent.
- The manufacturer shall specify the safe methods for changing and disposal of
 - any fuses accessible to the user, including type and ratings as per 6.1.4;
 - any replaceable batteries, for example, Lithium, and/or suitable replacements where applicable;
 - the method of safe re-charging and/or replacement for re-chargeable batteries with recommendation of suitable replacements where applicable;
 - the user shall be warned that where fibre-optic communication output devices are fitted, these should not be viewed directly.

Compliance with 6.2.4 is checked by inspection.

6.2.5 Equipment operation

Operating instructions for the equipment shall include the following:

- A statement indicating that it is the responsibility of the user to ensure that the equipment is installed, operated and used for its intended function in the manner specified by the manufacturer. Also that, if this is not the case, then any safety protection provided by the equipment may be impaired.
- An explanation of, and where possible pictures of, symbols used on the equipment according to 6.1.

6.3 Packaging

6.3.1 General

The scope of this standard does not cover the transportation of equipment between the manufacturer and the user. However, it shall be the manufacturer's responsibility to ensure that this transportation shall be carried out in a manner that ensures safe handling with respect to the equipment, transporter and user.

It is not possible to fully quantify any shocks and impacts likely to be experienced by equipment during its transportation to a user's site.

The manufacturer shall, therefore, ensure that the equipment is suitably packaged to withstand, without damage, reasonable handling and environmental conditions appropriate to the method(s) of transportation to the user's delivery address.

A visual inspection should be made by the user to check that the equipment has not been damaged during transportation.

6.3.2 Marking of packaging

6.3.2.1 General

Where appropriate the packaging of equipment shall be marked with the following:

FRAGILE HANDLE WITH CARE, ELECTRICAL EQUIPMENT.

- The manufacturer's name and/or logo.
- Equipment type reference.
- Where appropriate, to aid transportation, packages containing more than one piece of equipment, should be marked with the total 'multi-package' weight (in metric measures).

6.3.2.2 Additional warning labels, fitted as appropriate

The following are typical examples of the range shown in ISO 780:1997, Table 1.

Other symbols shown in this table may be used on packaging as deemed appropriate to the safe handling and delivery of equipment and the transport conditions to be used.

- '**FRAGILE**' warning. This may be written, in an approved language, pictorial according to symbol 1 of Table 1 of ISO 780:1997 or both.
- '**THIS WAY UP**' orientation indication according to symbol 2 of Table 1 of ISO 780:1997.
- '**KEEP DRY**' according to symbol 6 of Table 1 of ISO 780:1997.
- '**SLING HERE**' according to symbol 16 of Table 1 of ISO 780:1997.
- '**CENTRE OF GRAVITY**' according to symbol 7 of Table 1 of ISO 780:1997.

6.4 Dimensions

The manufacturer shall declare the dimensions of the equipment. However, where the equipment is rack mounted then the dimensions should be in accordance with IEC 60297-3-101.

Compliance with 6.4 is checked by measurement and inspection.

6.5 Functional performance requirements

The equipment shall meet the applicable requirements of the relevant IEC 61850 standards, for example IEC 61850-90-4 for Ethernet Switches/Routers.

6.6 Product safety requirements

6.6.1 Clearances and creepage distances

6.6.1.1 General

Where there is any doubt that the required clearance and creepage distances are compliant with the values in the appropriate table from Annex C of IEC 60255-27:2013, measurements shall be made. Where the minimum clearance value is not met, then the clearance may be proven by testing.

Testing to prove the clearance in air cannot be used to demonstrate compliance of the associated creepage distance.

Where a transient suppressor is used to reduce the overvoltage, the circuit shall be tested to show that it withstands the application of 10 positive and 10 negative impulses from a source impedance of 2 Ω . Surge test generator characteristics and impulse voltage amplitude for a differential and/or common mode supply input according to IEC 60255-26 shall be used.

6.6.1.2 Clearances for primary circuits

The clearances in air relating to primary circuits are determined by the rated impulse voltage (refer to C.1.4 of IEC 60255-27:2013).

Basic insulation is the minimum requirement between primary circuits and other circuits, (primary or non-primary circuits) including accessible parts and earthed parts. Additional insulation (for example, functional or supplementary insulation) may be required, depending upon the isolation class (see Annex B of IEC 60255-27:2013). To minimize the risk of fire, it is necessary to correctly design functional insulation, such as that across a primary circuit.

Where the clearance does not comply with the relevant Table C.3 to C.10 of IEC 60255-27:2013, this may be proven by testing using a test voltage determined by the multiplication of the withstand voltage, by the appropriate multiplication factor for altitude from Table C.11 of IEC 60255-27:2013. The preferred method to prove the product is safe, where the clearance is below the minimum specified value, is to use the a.c. or d.c. value given in the table, rather than the impulse voltage, unless the impulse voltage generator characteristics and impulse voltage amplitude are according to IEC 60255-22-5.

NOTE The withstand voltages in Tables C.1 to C.10 of IEC 60255-27:2013 are for inhomogeneous fields. In many cases, the clearance in air between two parts of the equipment is between inhomogeneous and homogeneous; hence, clearances can be proven by testing.

Interpolation of clearance values in Tables C.1 to C.12 of IEC 60255-27:2013 is not permitted for basic, supplementary, reinforced and double insulation. Interpolation of clearance values for functional insulation is permitted.

6.6.1.3 Clearances for non-primary circuits

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

Interpolation of the clearance values in Tables C.1 to C.12 in IEC 60255-27:2013 is permitted, for non-primary circuits.

6.6.1.4 Creepage distances

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

Creepage distances shall be determined with reference to Annex A and Annex C of IEC 60255-27:2013.

The design of creepage distance between any two circuits shall conform to the greater creepage distance of the two.

If pollution degree 3 or 4 causes persistent conductivity, for example, due to carbon or metal dust, the dimensions for creepage distances cannot be specified. Instead, the surface of insulation has to be designed to avoid a continuous path (for example, by means of ribs or grooves, of at least 2 mm height or depth) of conductive pollution.

Table C.12 of IEC 60255-27:2013 indicates additional protection which may be used to reduce the pollution degree within the equipment. If Table C.12 of IEC 60255-27:2013 is used to determine reduced creepage distance, it should be ensured that this is not less than the minimum allowed clearance.

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

Interpolation of creepage distances in Tables C.1 to C.12 of IEC 60255-27:2013 is permitted, for both primary and non-primary circuits.

6.6.2 IP rating

This test is to verify that equipment cases, barriers or mounting panels prevent hazardous live parts being accessible in normal operational use.

This test shall be carried out as a type test for the equipment to verify that hazardous live parts cannot be accessed by the standard jointed test finger for IP2X in IEC 60529 and that the test finger voltage or energy does not exceed the safe limits for normal operational use.

a) Voltage levels: 33 V a.c. or 70 V d.c.

For equipment rated for use in wet locations, the voltage levels are 25 V a.c. or 37,5 V d.c.

b) Current levels (see Table 5):

Table 5 – Current levels in normal operational condition

Installation location	Figure 3/Figure 5 of IEC 60990:1999 Measurement circuit to be used	Sinusoidal waveforms	Non-sinusoidal or mixed frequency waveforms	
		mA r.m.s.	mA peak	mA d.c.
Dry	Figure 4	0,5	0,7	2
Wet	Figure 3 with $R_s = 375 \Omega$ (instead of 1500Ω)	0,5	0,7	2
Dry	Figure 3 with $R_s = 75 \Omega$ Relates to possible burns in the frequency range 30 kHz to 500 kHz	70	-----	-----

c) Charge or energy of capacitance levels (see Table 6):

Table 6 – Charge of energy of capacitance levels

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

Unless otherwise agreed, tests shall be carried out to confirm that the equipment case meets the manufacturer's claimed IP class in normal operational use. The tests shall be in accordance with those specified in IEC 60529 for the equipment case class.

6.6.3 Impulse voltage

6.6.3.1 General

The impulse voltage type test is carried out with a voltage having a 1,2/50 μs waveform (see Figure 1 of IEC 61180-1:1992), and is intended to simulate over voltages of atmospheric origin. It also covers over voltages due to switching of low-voltage equipment.

6.6.3.2 Test procedures

The impulse voltage test shall be carried out in accordance with the following.

The impulse voltage shall be applied to the appropriate points accessible from the outside of the equipment, the other circuits and the exposed conductive parts shall be connected together and to earth.

The tests for verification of clearances shall be conducted for a minimum of three impulses of each polarity with an interval of at least 1 s between impulses.

The same test procedure also applies for the verification of the capability of solid insulation; however, five impulses of each polarity shall be applied in this case, and the wave shape of each impulse shall be recorded.

Both tests, for verification of clearances and for verification of solid insulation, may be combined in one common test procedure.

6.6.3.3 Waveform and generator characteristics

A standard impulse voltage in accordance with IEC 61180-1 shall be used. The generator characteristics shall be verified according to IEC 61180-2.

The parameters are:

- front time: $1,2 \mu\text{s} \pm 30 \%$;
- time to half-value: $50 \mu\text{s} \pm 20 \%$;
- output impedance: $500 \Omega \pm 10 \%$;
- output energy: $0,5 \text{ J} \pm 10 \%$.

The length of each test lead shall not exceed 2 m.

6.6.3.4 Selection of impulse test voltage

6.6.3.4.1 General

The applicable rated impulse test voltage shall be selected from one of the following nominal values: 0 kV, 1 kV, 5 kV peak.

When zero-rated impulse test is specified for particular equipment circuits, these shall be exempt from the impulse voltage test.

The specified impulse test of 5 kV peak applies to altitudes up to 200 m. For altitudes above 200 m, Table C.11 of IEC 60255-27:2013 shall be used to reduce the test voltage.

The test voltage tolerance shall be $+0 \%$, -10% .

When the test is between two independent equipment circuits, the higher of the two rated impulse voltages shall be used for the test.

6.6.3.4.2 Equipment to be tested at 5 kV peak nominal

An equipment circuit, classed as a primary circuit, according to Clause 3, shall be tested at 5 kV peak nominal, in accordance with 6.6.3.3.

6.6.3.4.3 Equipment to be tested at 1 kV peak nominal

Equipment circuits may be tested at 1 kV peak nominal, in accordance with 6.6.3.3, if the following apply:

- the auxiliary (power supply) circuits are connected to a battery used exclusively for the power supply of equipment covered by this standard. This battery shall not be used for switching inductive loads;
- the equipment is not powered via current or voltage transformers;
- I/O circuits required to be tested are not subjected to induced or inductive load transients in excess of 1 kV peak.

6.6.3.4.4 Performing of tests

The impulse voltage type test is applicable whether or not the equipment under test is fitted with surge suppression.

Unless otherwise specified, the impulse voltage test shall be performed

- between each circuit (or each group of circuits) specified for the same impulse voltage and the exposed conductive parts at the impulse voltage specified for this circuit (or this group of circuits);
- between independent circuits, the terminals of each independent circuit being connected together;
- across the terminals of a given circuit to validate the manufacturer's claim.

Circuits not involved in the tests shall be connected together and to earth.

Unless obvious, the independent circuits are those which are so described by the manufacturer.

For equipment with an insulated case, the exposed conductive parts shall be represented by a metal foil covering the whole equipment case except the terminals around which a suitable gap shall be left so as to avoid flashover to the terminals. The test between two independent circuits shall be carried out, unless otherwise specified, at the higher impulse voltage specified for the two circuits.

It is permissible for an impulse voltage waveform applied across test points connected to surge suppression, inductive devices or potential dividers, to be attenuated or distorted if this is not due to electrical breakdown.

The waveform applied to test points not connected to such devices, will not be noticeably distorted or attenuated unless the insulation does not withstand the impulse voltage test.

6.6.3.4.5 Test acceptance criteria

There shall be no disruptive discharge (spark-over, flashover or puncture) during test. Partial discharges in clearances which do not result in breakdown are disregarded. After this type test, the equipment shall comply with all relevant performance requirements.

6.6.3.4.6 Repetition of the impulse voltage test

For equipment in a new condition, impulse voltage tests may be repeated, if necessary, to verify performance. The test voltage value shall be equal to 0,75 times the value originally specified or indicated by the manufacturer.

6.6.4 AC or d.c. dielectric voltage test

6.6.4.1 Performing the dielectric voltage test

6.6.4.1.1 Type tests

Type tests shall be applied

- between each circuit and the accessible conductive parts, the terminals of each independent circuit being connected together;
- between independent circuits, the terminals of each independent circuit being connected together.

Unless obvious, the independent circuits are those which are so described by the manufacturer.

If applicable, the manufacturer shall declare the dielectric voltage withstand, for open metallic contacts and verify this by type testing. No test should be applied across contacts when transient suppression devices are fitted. Circuits not involved in the tests shall be connected together and to earth.

Circuits specified for the same rated insulation voltage may be connected together when being tested to the exposed conductive parts.

The test voltages shall be applied directly to the terminals.

For equipment with an insulating case, the exposed conductive parts shall be represented by a metal foil covering the whole equipment case except the terminals around which a suitable gap shall be left so as to avoid flashover to the terminals. Insulation tests requiring this metal foil shall be performed as type tests only.

6.6.4.1.2 Routine tests

Routine dielectric voltage tests shall be applied between each independent circuit and the accessible conductive parts, the terminals of each independent circuit being connected together.

6.6.4.1.3 Routine tests by sampling

Sample testing of the assembled equipment may be carried out if the following points are met.

- The fully assembled printed circuit cards or modules are 100 % routine tested.
- The manufacturer has carried out a risk analysis and documented that, due to the design and build of the equipment, for all build variations, there is a very low probability of safety risks due to any build and handling problems, when the routine tested items are assembled into the equipment.
- Any sample testing is carried out to a documented sampling plan.

Tests shall be performed between each independent circuit and the accessible conductive parts, the terminals of each independent circuit being connected together.

The minimum number of samples, randomly chosen from the batch to be tested, shall be two.

The acceptance criteria for this safety test shall be: accept on zero failures, reject on one failure.

In the case of a batch rejection, the batch shall either be 100 % tested, or after investigation and rectification of the cause of failure the batch may be re-tested to the documented sampling plan.

6.6.4.2 Value of the dielectric test voltage

Dielectric voltage tests shall be made by applying the appropriate voltages in Table 7. The test voltage should be declared by the manufacturer.

Table 7 – AC test voltages

Rated insulation voltage V	AC test voltage, 1 min kv
Up to 63	0,5
125 to 500	2,0
630	2,3
800	2,6
1000	3,0

For circuits directly energized via instrument transformers (VTs and standard CTs), or connected to a station battery the test voltage shall not be less than 2,0 kV r.m.s., 1 min.

Where this is not the case, Table 7 may be used to determine the appropriate test voltage.

A higher test voltage of 2,5 kV r.m.s. 1 min for CT circuits may be claimed by the manufacturer. Higher test voltages shall be specified for pilot wire circuits where short-circuit current induced over voltages on the pilot wires are to be expected. The applicable test voltage shall, in this case, be declared by the manufacturer.

For common circuits such as CTs, VTs and digital inputs connected by a common connection to earth or neutral, a test voltage of 500 V may be used. If applicable, the manufacturer shall declare the dielectric voltage withstand for open metallic contacts and verify this by type testing. No test shall be applied across contacts when transient suppression devices are fitted.

6.6.4.3 Test voltage source

The test voltage source shall be such that, when applying half the specified value to the EUT (equipment under test), the voltage drop observed is less than 10 %.

The source voltage value shall be verified with an accuracy better than 5 %.

The test voltage shall be substantially sinusoidal and at a frequency between 45 Hz and 65 Hz. However, tests may alternatively be performed with a d.c. voltage the value of which shall be 1,4 times that given in Table 7.

Use of capacitors to earth for EMC compliance will lead to increased test current and thus make detection of a breakdown condition difficult. This problem can be overcome by using a d.c. test voltage ($\sqrt{2} \times$ r.m.s.) or by measuring a.c. resistive current only.

6.6.4.4 Test method

For type tests the open-circuit voltage of the test generator is applied to the equipment at zero volts. The test voltage shall be raised smoothly to the specified value in such a manner that no appreciable transients occur and shall be maintained for 1 min minimum. It shall then be reduced smoothly to zero as rapidly as possible.

For routine tests, the test voltage may be maintained for 1 s minimum. In this case, the test voltage shall be 10 % higher than the specified 1 min type test voltage.

6.6.4.5 Test acceptance criteria

During the dielectric voltage test, no breakdown or flashover shall occur. Partial discharges which do not cause the maximum test current level set by the manufacturer to be exceeded shall be disregarded.

6.6.4.6 Repetition of the dielectric voltage test (a.c. power-frequency high-voltage test)

For equipment in a new condition, dielectric voltage tests may be repeated, if necessary, to verify their performance. The test voltage value shall be equal to 0,75 times the value claimed by the manufacturer.

6.6.5 Protective bonding resistance

6.6.5.1 Protective bonding resistance – type test

Exposed conductive parts and terminations connected to the protective conductor for protection against any electric shock hazard shall not have excessive resistance.

For equipment where the protective conductor connection is by means of one core of a multi cored cable, the cable is not included in the measurement, provided that the cable is supplied by a suitably rated protective device which takes into account the size of the conductor.

The compliance of such parts with protective bonding resistance type test requirements shall be determined using the following test parameters:

- the test current shall be twice that of the maximum current rating of the overcurrent protection means, specified in the user documentation;
- the test voltage shall not exceed 12 V r.m.s. a.c. or 12 V d.c.;
- the test duration shall be 60 s;
- the resistance between the protective conductor terminal and the part under test shall not exceed 0,1 Ω .

6.6.5.2 Protective bonding continuity – routine test

Accessible conductive parts which may become live in the event of a single-fault condition shall be subject to a low current continuity test to verify their bonding to the protective conductor terminal.

It is recommended that the continuity tester open-circuit voltage and short-circuit current should be chosen to avoid any circuit damage.

6.6.6 Flammability of insulation materials, components and fire enclosure

6.6.6.1 General

Testing of plastic parts may be necessary where either the material does not meet the minimum flammability specified, or its thickness is below the minimum specified for that material to achieve the required minimum flammability.

Tests may be required to determine the flammability of insulating materials and components and fire enclosures.

6.6.6.2 Flammability specifications

6.6.6.2.1 General

Except as specified in 6.6.6.2.2 to 6.6.6.2.4 all materials and components shall comply with the following:

- insulated wire shall have a flammability class equivalent V-1, or better, of IEC 60695-11-10;
- connectors and insulating material on which components are mounted shall have a flammability class V-2, or better, of IEC 60695-11-10.

Conformity is checked by inspection of data on materials, or by performing the flammability tests specified in IEC 60695-11-10 on three samples of the relevant parts. The samples may be any of the following:

- complete parts;
- sections of a part, including the area with the least wall thickness and any ventilation openings;
- specimens in accordance with IEC 60695-11-10.

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

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

6.6.6.2.2 Materials for components and other parts inside fire enclosures

The following are exempted from the requirements of 6.6.6.2.1.

- Electrical components which do not present a fire hazard under abnormal operating conditions.
- Materials and components within an equipment case of volume 0,06 m³ or less, consisting totally of metal and having no ventilation openings, or within a sealed unit containing an inert gas.
- One or more layers of thin insulating material, such as adhesive tape, used directly on any surface within the fire enclosure, including the surface of current-carrying parts, provided that the combination of the thin insulating material and the surface of application comply with the requirements of flammability Class V-2, or better, of IEC 60695-11-10.
- Electronic components, such as integrated circuit packages, opto-coupler packages, capacitors and other small parts mounted on material of flammability Class V-1, or better, of IEC 60695-11-10.
- Wiring, cables and connectors insulated with PVC, TFE, PTFE, FEP or neoprene or polyimide.
- Individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties used with wiring harnesses.

Compliance with 6.6.6.2.1 and 6.6.6.2.2 is checked by inspection of the equipment and material data sheets.

6.6.6.2.3 Materials for fire enclosures

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

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

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

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