

Specification for

Low-voltage switchgear and controlgear assemblies

Part 1. Specification for type-tested and partially type-tested assemblies

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Summary of pages

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National foreword

This British Standard has been prepared by Subcommittee PEL/17/3 (formerly PEL/12), and is the English language version of EN 60439-1 : 1994 *Low-voltage switchgear and controlgear assemblies Part 1: Type-tested and partially type-tested assemblies*, including corrigenda 1994 and 1995, amendment A1 : 1995 and amendment A11 : 1996, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by CENELEC from IEC 439-1 : 1992 including Corrigendum 1993 and amendment 1 : 1995, published by the International Electrotechnical Commission (IEC).

BS 5486 : Part 1 : 1990 (EN 60439-1 : 1990) remains applicable for use with BS EN 60439-2 : 1993, BS EN 60439-3 : 1991 and BS EN 60439-4 : 1991.

Amendment 1 : 1993 to BS 5486 : Part 1 : 1990 included a new national appendix NA which reproduced the text of IEC Technical Report 1117 : 1992 for the reader's information. With the withdrawal of BS 5486 : Part 1 : 1990, it is intended to publish IEC Technical Report 1117 : 1992 separately as a dual-numbered British Standard.

The following print types are used in this standard:

- requirements proper: in roman type
- *test specifications: in italic type*
- explanatory matter: in small roman type

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Descriptors: Switchgear and controlgear, low voltage, switchgear and controlgear assembly, type tested assembly, partially type tested assembly, definitions, characteristics, tests

English version

Low-voltage switchgear and controlgear assemblies Part 1: Type-tested and partially type-tested assemblies (includes amendments A1 : 1995 + A11 : 1996)

(IEC 439-1 : 1992 + corrigendum 1993 + A1 : 1995)

Ensembles d'appareillage à basse tension
Partie 1: Ensembles de série et ensembles dérivés
de série (inclut les amendements A1 : 1995
+ A11 : 1996)
(CEI 439-1 : 1992 + corrigendum 1993
+ A1 : 1995)

Niederspannung-Schaltgeräte-kombinationen
Teil 1: Typgeprüfte und partiell typgeprüfte
Kombinationen (enthält Änderungen A1 : 1995
+ A11 : 1996)
(IEC 439-1 : 1992 + Corrigendum 1993
+ A1 : 1995)

This European Standard was approved by CENELEC on 1993-12-08. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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CENELEC

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

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Foreword

At the request of the CENELEC Technical Committee TC 17D, Low-voltage switchgear and controlgear assemblies, the International Standard IEC 439-1 : 1992 was submitted to the CENELEC Unique Acceptance Procedure (UAP) in March 1993 for acceptance as a European Standard.

The text of the International Standard and its corrigendum December 1993 was approved by CENELEC as EN 60439-1 on 8 December 1993.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1994-10-01
- latest date of withdrawal of conflicting national standards (dow) 1994-10-01

For products which have complied with EN 60439-1 : 1990 and its amendment A1 : 1993 before 1994-10-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1999-10-01.

|| NOTE. EN 60439-1 : 1990 remains applicable for use with EN 60439-2 : 1993, EN 60439-3 : 1991 and EN 60439-4 : 1991.

Annexes designated 'normative' are part of the body of the standard. Annexes designated 'informative' are given only for information. In this standard, annexes A, B, F, G and ZA are normative and annexes C, D, E and H are informative.

Foreword to amendment A1

The text of document 17D/156/DIS, future amendment 1 to IEC 439-1 : 1992, prepared by SC 17D, Low-voltage switchgear and controlgear assemblies, of IEC TC 17, Switchgear and controlgear, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60439-1 : 1994 on 1995-11-28.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-09-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-09-01

For products which have complied with EN 60439-1 : 1994 before 1996-09-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-09-01.

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative. Annex ZA has been added by CENELEC.

Foreword to amendment A11

This amendment was prepared by the CENELEC Technical Committee TC17D, Low-voltage switchgear and controlgear assemblies.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as amendment A11 to EN 60439-1 : 1994 on 1995-11-28.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-11-01

For products which have complied with EN 60439-1 : 1994 and its amendment A1 : 1995 before 1996-11-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-11-01.

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

Part 1: Type-tested and partially type-tested assemblies

1 General

1.1 *Scope and object*

This International Standard applies to low-voltage switchgear and controlgear assemblies (type-tested assemblies (TTA) and partially type-tested assemblies (PTTA)), the rated voltage of which does not exceed 1 000 V a.c. at frequencies not exceeding 1 000 Hz, or 1 500 V d.c.

This standard also applies to assemblies incorporating control and/or power equipment, the frequencies of which are higher. In this case, appropriate additional requirements shall apply.

This standard applies to stationary or movable assemblies with or without enclosure.

NOTE - Additional requirements for certain specific types of assemblies are given in supplementary IEC standards.

This standard applies to assemblies intended for use in connection with generation, transmission, distribution and conversion of electric energy and for the control of electric energy consuming equipment.

It also applies to such assemblies designed for use under special service conditions, for example in ships, in rail vehicles, for machine tools, for hoisting equipment, or in explosive atmospheres, and for domestic (operated by unskilled persons) applications, provided that the relevant specific requirements are complied with.

This standard does not apply to individual devices and self-contained components, such as motor starters, fuse switches, electronic equipment, etc., complying with their relevant standards.

The object of this standard is to lay down the definitions and to state the service conditions, construction requirements, technical characteristics and tests for low-voltage switchgear and controlgear assemblies.

1.2 *Normative references*

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 38: 1983, *IEC standard voltages*.

IEC 50(441): 1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*.

IEC 50(471): 1984, *International Electrotechnical Vocabulary (IEV) – Chapter 471: Insulators*.

IEC 50(604): 1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*.

IEC 60 *High-voltage test techniques*

IEC 71-1: 1976, *Insulation co-ordination – Part 1: Terms, definitions, principles and rules*.

IEC 73: 1991, *Coding of indicating devices and actuators by colours and supplementary means*.

IEC 99-1: 1991, *Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems*.

IEC 112: 1979, *Method for determining the comparative and the proof-tracking indices of solid insulating materials under moist conditions*.

IEC 146-2: 1974, *Semiconductor convertors – Part 2: Semiconductor self-commutated convertors*.

IEC 158-2: 1982, *Low-voltage controlgear – Part 2: Semiconductor contactors (solid state contactors)*.

IEC 227-3: 1993, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*.

IEC 227-4: 1992, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 4: Sheathed cables for fixed wiring*.

IEC 245-3: 1994, *Rubber insulated cables of rated voltages up to and including 450/750 V – Part 3: Heat resistant silicone insulated cables*.

IEC 245-4: 1994, *Rubber insulated cables of rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables*.

IEC 269, *Low-voltage fuses*.

IEC 364-3: 1977, *Electrical installations of buildings – Part 3: Assessment of general characteristics*.

IEC 364-4-41: 1992, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock*.

IEC 364-4-481: 1993, *Electrical installations of buildings – Part 4: Protection for safety – Section 481: Choice of protective measures against electric shock in relation to external influences* (in preparation).

IEC 364-5-54: 1980, *Electrical installations of buildings – Part 5: Selection and erection of electrical equipment – Chapter 54: Earthing arrangements and protective conductors*.

IEC 417: 1973, *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*.

IEC 445: 1988, *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*.

IEC 446: 1989, *Identification of conductors by colours or numerals*.

IEC 447: 1974, *Standard directions of movement for actuators which control the operation of electrical apparatus*.

|| IEC 502: 1994, *Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV*.

IEC 529: 1989, *Degrees of protection provided by enclosures (IP Code)*.

IEC 664-1: 1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Basic principles and requirements*.

IEC 750: 1983, *Item designation in electrotechnology*.

IEC 890: 1987, *A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear*.

IEC 947-1: 1988, *Low-voltage switchgear and controlgear – Part 1: General rules*.

IEC 947-3: 1990, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*.

IEC 947-4-1: 1990, *Low-voltage switchgear and controlgear – Part 4: Contactors and motor-starters – Section 1: Electromechanical contactors and motor-starters*.

|| EN 50081-1 1992 *Electromagnetic compatibility – Generic emission standard*
Part 1: Residential, commercial and light industry

EN 50081-2 1993 Part 2: Industrial environment

|| EN 50082-1 1992 *Electromagnetic compatibility – Generic immunity standard*
Part 1: Residential, commercial and light industry

EN 50082-2 1995 Part 2: Industrial environment

2 Definitions

For the purpose of this International Standard, the following definitions apply.

NOTE - Certain definitions in this clause are taken unchanged or modified from those of IEC 50 (IEV) or from other IEC publications.

2.1 General

2.1.1 Low-voltage switchgear and controlgear assembly (ASSEMBLY)

A combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts (see 2.4).

NOTES

- 1 Throughout this standard, the abbreviation ASSEMBLY is used for a low-voltage switchgear and controlgear assembly.
- 2 The components of the ASSEMBLY may be electromechanical or electronic.
- 3 For various reasons, for example transport or production, certain steps of assembly may be made in a place outside the factory of the manufacturer.

2.1.1.1 *Type-tested low-voltage switchgear and controlgear assembly (TTA)*

A low-voltage switchgear and controlgear assembly conforming to an established type or system without deviations likely to significantly influence the performance, from the typical ASSEMBLY verified to be in accordance with this standard.

NOTES

- 1 Throughout this standard, the abbreviation TTA is used for a type-tested low-voltage switchgear and controlgear assembly.
- 2 For various reasons, for example transport or production, certain steps of assembly may take place outside the factory of the manufacturer of the TTA. Such an ASSEMBLY is considered as a TTA provided the assembly is performed in accordance with the manufacturer's instructions in such a manner that compliance of the established type or system with this standard is assured, including submission to applicable routine test.

2.1.1.2 *Partially type-tested low-voltage switchgear and controlgear assembly (PTTA)*

A low-voltage switchgear and controlgear assembly, containing both type-tested and non-type-tested arrangements provided that the latter are derived (e.g. by calculation) from type-tested arrangements which have complied with the relevant tests (see table 7).

NOTE - Throughout this standard, the abbreviation PTTA is used for a partially type-tested switchgear and controlgear assembly.

2.1.2 *Main circuit (of an ASSEMBLY)*

All the conductive parts of an ASSEMBLY included in a circuit which is intended to transmit electrical energy. [IEV 441-13-02]

2.1.3 *Auxiliary circuit (of an ASSEMBLY)*

All the conductive parts of an ASSEMBLY included in a circuit (other than the main circuit) intended to control, measure, signal, regulate, process data, etc. [IEV 441-13-03 modified]

NOTE - The auxiliary circuits of an ASSEMBLY include the control and the auxiliary circuits of the switching devices.

2.1.4 *Busbar*

A low-impedance conductor to which several electric circuits can be separately connected.

|| NOTE - The term busbar does not presuppose the geometrical shape, size or dimensions of the conductor.

2.1.4.1 *Main busbar*

A busbar to which one or several distribution busbars and/or incoming and outgoing units can be connected.

2.1.4.2 *Distribution busbar*

A busbar within one section which is connected to a main busbar and from which outgoing units are supplied.

2.1.5 *Functional unit*

A part of an ASSEMBLY comprising all the electrical and mechanical elements that contribute to the fulfilment of the same function.

2.1.6 *Incoming unit*

A functional unit through which electrical energy is normally fed into the ASSEMBLY.

2.1.7 *Outgoing unit*

A functional unit through which electrical energy is normally supplied to one or more outgoing circuits.

2.1.8 *Functional group*

A group of several functional units which are electrically interconnected for the fulfilment of their operational functions.

2.1.9 *Test situation*

A condition of an ASSEMBLY or part of it in which the relevant main circuits are open but not necessarily disconnected (isolated) whilst the associated auxiliary circuits are connected, allowing tests of the operation of incorporated devices.

2.1.10 *Disconnected situation*

A condition of an ASSEMBLY or a part of it in which the relevant main circuit and associated auxiliary circuits are disconnected (isolated).

2.1.11 *Connected situation*

A condition of an ASSEMBLY or a part of it in which the relevant main circuit and associated auxiliary circuits are connected for their normally intended function.

2.2 *Constructional units of ASSEMBLIES*

2.2.1 *Section* (see figure C.4, page 165):

A constructional unit of an ASSEMBLY between two successive vertical delineations.

2.2.2 *Sub-section*

A constructional unit of an ASSEMBLY between two successive horizontal delineations within a section.

2.2.3 *Compartment*

A section or sub-section enclosed except for openings necessary for interconnection, control or ventilation.

2.2.4 *Barriered section or sub-section*

A section or sub-section fitted with barriers designed and arranged to protect against direct contact with adjacent equipment when handling the elements in the section or sub-section.

2.2.5 *Transport unit*

A part of an ASSEMBLY or a complete ASSEMBLY suitable for shipping without being dismantled.

2.2.6 *Fixed part* (see figure C.9, page 170)

A part consisting of components assembled and wired on a common support and which is designed for fixed installation (see 7.6.3).

2.2.7 *Removable part*

A part which may be removed entirely from the ASSEMBLY and replaced even though the circuit to which it is connected may be live.

2.2.8 *Withdrawable part* (see figure C.10, page 171)

A removable part which can be moved from the connected position to the disconnected position and to a test position, if any, whilst remaining mechanically attached to the ASSEMBLY.

NOTE - This isolating distance may relate either to the main circuits only or to the main circuits and the auxiliary circuits (see 2.2.11), see also table 6 (page 97).

2.2.9 *Connected position*

The position of a removable or withdrawable part when it is fully connected for its normally intended function.

2.2.10 *Test position*

A position of a withdrawable part in which the relevant main circuits are open on its supply side but not necessarily disconnected (isolated) and in which the auxiliary circuits are connected, allowing tests of the operation of the withdrawable part, that part remaining mechanically attached to the ASSEMBLY.

NOTE - The opening may also be achieved without any mechanical movement of the withdrawable part by operation of a suitable device.

2.2.11 *Disconnected position (isolated position)*

A position of a withdrawable part in which an isolating distance (see 7.1.2.2) is established in main and auxiliary circuits, the withdrawable part remaining mechanically attached to the ASSEMBLY.

NOTE - The isolating distance may also be established without any mechanical movement of the withdrawable part by operation of a suitable device.

2.2.12 *Removed position*

The position of a removable or withdrawable part when it is outside the ASSEMBLY and mechanically and electrically separated from it.

2.2.13 *Electrical connections of functional units*

2.2.13.1 *Fixed connection*

A connection which is connected or disconnected by means of a tool.

2.2.13.2 *Disconnectable connection*

A connection which is connected or disconnected by manual operation of the connecting means without a tool.

2.2.13.3 *Withdrawable connection*

A connection which is connected or disconnected by bringing the functional unit into the connected or disconnected situation.

2.3 *External design of ASSEMBLIES*

2.3.1 *Open-type ASSEMBLY* (see figure C.1, page 162)

An ASSEMBLY consisting of a supporting structure which supports the electrical equipment, the live parts of the electrical equipment being accessible.

2.3.2 *Dead-front ASSEMBLY* (see figure C.2, page 163)

An open-type ASSEMBLY with a front covering which provides a degree of protection of at least IP2X from the front. Live parts may be accessible from the other directions.

2.3.3 *Enclosed ASSEMBLY*

An ASSEMBLY which is enclosed on all sides with the possible exception of its mounting surface in such a manner as to provide a degree of protection of at least IP2X.

2.3.3.1 Cubicle-type ASSEMBLY (see figure C.3, page 164)

An enclosed ASSEMBLY in principle of the floor-standing type which may comprise several sections, sub-sections or compartments.

2.3.3.2 Multi-cubicle-type ASSEMBLY (see figure C.4, page 165)

A combination of a number of mechanically joined cubicles.

2.3.3.3 Desk-type ASSEMBLY (see figure C.5, page 166)

An enclosed ASSEMBLY with a horizontal or inclined control panel or a combination of both, which incorporates control, measuring, signalling, etc., apparatus.

2.3.3.4 Box-type ASSEMBLY (see figure C.6, page 167)

An enclosed ASSEMBLY, in principle intended to be mounted on a vertical plane.

2.3.3.5 Multi-box-type ASSEMBLY (see figure C.6, page 167)

A combination of boxes mechanically joined together, with or without a common supporting frame, the electrical connections passing between two adjacent boxes through openings in the adjoining faces.

2.3.4 Busbar trunking system (busway) (see figure C.7, page 168)

A type-tested assembly in the form of a conductor system comprising busbars which are spaced and supported by insulating material in a duct, trough or similar enclosure. [IEV 441-12-07 modified]

The ASSEMBLY may consist of units such as

- busbar trunking units with or without tap-off facilities;
- phase transposition, expansion, flexible, feeder and adapter units;
- tap-off units.

NOTE - The term "busbar" does not presuppose the geometrical shape, size and dimensions of the conductor.

2.4 Structural parts of ASSEMBLIES

2.4.1 Supporting structure (see figure C.1, page 162)

A structure forming part of an ASSEMBLY designed to support various components of an ASSEMBLY and an enclosure, if any.

2.4.2 Mounting structure (see figure C.8, page 169)

A structure not forming part of an ASSEMBLY designed to support an enclosed ASSEMBLY.

2.4.3 *Mounting panel* * (see figure C.9, page 170)

A panel designed to support various components and suitable for installation in an ASSEMBLY.

2.4.4 *Mounting frame* * (see figure C.9, page 170)

A framework designed to support various components and suitable for installation in an ASSEMBLY.

2.4.5 *Enclosure*

A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact to a degree of protection of at least IP2X.

2.4.6 *Cover*

A part of the external enclosure of an ASSEMBLY.

2.4.7 *Door*

A hinged or sliding cover.

2.4.8 *Removable cover*

A cover which is designed for closing an opening in the external enclosure and which can be removed for carrying out certain operations and maintenance work.

2.4.9 *Cover plate*

A part of an ASSEMBLY – in general of a box (see 2.3.3.4) – which is used for closing an opening in the external enclosure and designed to be held in place by screws or similar means. It is not normally removed after the equipment is put into service.

NOTE - The cover plate can be provided with cable entries.

2.4.10 *Partition*

A part of the enclosure of a compartment separating it from other compartments.

2.4.11 *Barrier*

A part providing protection against direct contact from any usual direction of access (minimum IP2X) and against arcs from switching devices and the like, if any.

2.4.12 *Obstacle*

A part preventing unintentional direct contact, but not preventing deliberate action.

* If these structural parts incorporate apparatus, they may constitute self-contained ASSEMBLIES.

2.4.13 *Shutter*

A part which can be moved:

- between a position in which it permits engagement of the contacts of removable or withdrawable parts with fixed contacts, and
- a position in which it becomes a part of a cover or a partition shielding the fixed contacts. [IEV 441-13-07 modified]

2.4.14 *Cable entry*

A part with openings which permit the passage of cables into the ASSEMBLY.

NOTE - A cable entry can at the same time be designed as a cable sealing end.

2.4.15 *Spare spaces*

2.4.15.1 *Free space*

An empty space of a section.

2.4.15.2 *Unequipped space*

A part of a section incorporating busbars only.

2.4.15.3 *Partially equipped space*

A part of a section fully equipped except for the functional units. The functional units which can be installed are defined in number of modules and size.

2.4.15.4 *Fully equipped space*

A part of a section fully equipped with functional units not assigned to a specific use.

2.5 *Conditions of installation of ASSEMBLIES*

2.5.1 *ASSEMBLY for indoor installation*

An ASSEMBLY which is designed for use in locations where the usual service conditions for indoor use as specified in 6.1 of this standard are fulfilled.

2.5.2 *ASSEMBLY for outdoor installation*

An ASSEMBLY which is designed for use under the usual service conditions for outdoor use as specified in 6.1 of this standard.

2.5.3 *Stationary ASSEMBLY*

An ASSEMBLY which is designed to be fixed at its place of installation, for instance to the floor or to a wall, and to be used at this place.

2.5.4 *Movable ASSEMBLY*

An ASSEMBLY which is designed so that it can readily be moved from one place of use to another.

2.6 *Protective measures with regard to electric shock*

2.6.1 *Live part*

A conductor or conductive part intended to be energized in normal use, including a neutral conductor but, by convention, not a PEN conductor. [IEV 826-03-01]

NOTE - This term does not necessarily imply a risk of electric shock.

2.6.2 *Exposed conductive part*

A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions. [IEV 826-03-02 modified]

2.6.3 *Protective conductor (PE)*

A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts:

- exposed conductive parts;
- extraneous conductive parts;
- main earthing terminal;
- earth electrode;
- earthed point of the source or artificial neutral. [IEV 826-04-05]

2.6.4 *Neutral conductor (N)*

A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy. [IEV 826-01-03]

2.6.5 *PEN conductor*

An earthed conductor combining the functions of both protective conductor and neutral conductor. [IEV 826-04-06 modified]

2.6.6 *Fault current*

A current resulting from an insulation failure or the bridging of insulation.

2.6.7 *Earth fault current*

A fault current which flows to earth.

2.6.8 *Protection against direct contact*

Prevention of dangerous contact of persons with live parts.

2.6.9 Protection against indirect contact

Prevention of dangerous contact of persons with exposed conductive parts.

2.7 Gangways within ASSEMBLIES

2.7.1 Operating gangway within an ASSEMBLY

A space which must be used by the operator for the proper operation and supervision of the ASSEMBLY.

2.7.2 Maintenance gangway within an ASSEMBLY

A space which is accessible to authorized personnel only and primarily intended for use when servicing the installed equipment.

2.8 Electronic functions

2.8.1 Screening

Protection of conductors or equipment against interference caused in particular by electromagnetic radiation from other conductors or equipment.

2.9 Insulation co-ordination

2.9.1 Clearance

The distance between two conductive parts along a string stretched the shortest way between these conductive parts. [2.5.46 of IEC 947-1] [IEV 441-17-31]

2.9.2 Isolating distance (of a pole of a mechanical switching device)

The clearance between open contacts meeting the safety requirements specified for disconnectors. [2.5.50 of IEC 947-1] [IEV 441-17-35]

2.9.3 Creepage distance

The shortest distance along the surface of an insulating material between two conductive parts. [2.5.51 of IEC 947-1] [IEV 471-01-08 modified]

NOTE - A joint between two pieces of insulating material is considered part of the surface.

2.9.4 Working voltage

The highest value of the a.c. (r.m.s.) or d.c. voltage which may occur (locally) across any insulation at rated supply voltage, transients being disregarded, in open circuit conditions or under normal operating conditions. [2.5.52 of IEC 947-1]

2.9.5 Temporary overvoltage

The phase-to-earth, phase-to-neutral or phase-to-phase overvoltage at a given location and of relatively long duration (several seconds). [2.5.53 of IEC 947-1] [IEV 604-03-12 modified]

2.9.6 Transient overvoltages

The transient overvoltages in the sense of this standard are the following [2.5.54 of IEC 947-1]:

2.9.6.1 Switching overvoltage

A transient overvoltage at a given location on a system due to a specific switching operation or fault. [2.5.54.1 of IEC 947-1] [IEV 604-03-29 modified]

2.9.6.2 Lightning overvoltage

A transient overvoltage at a given location on a system due to a specific lightning discharge (see also IEC 60 and IEC 71-1). [2.5.54.2 of IEC 947-1]

2.9.7 Impulse withstand voltage

The highest peak value of an impulse voltage, of prescribed form and polarity, which does not cause breakdown under specified conditions of test. [2.5.55 of IEC 947-1]

2.9.8 *Power-frequency withstand voltage*

The r.m.s. value of a power-frequency sinusoidal voltage which does not cause breakdown under specified conditions of test. [2.5.56 of IEC 947-1] [IEV 604-03-40 modified]

2.9.9 *Pollution*

Any condition of foreign matter, solid, liquid or gaseous (ionized gases), that may affect dielectric strength or surface resistivity. [2.5.57 of IEC 947-1]

2.9.10 *Pollution degree (of environmental conditions)*

A conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt and on the relative humidity and its frequency of occurrence resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity.

NOTES

- 1 The pollution degree to which the insulating materials of devices and components are exposed may be different from that of the macro-environment where the devices or components are located because of protection offered by means such as an enclosure or internal heating to prevent absorption or condensation of moisture.
- 2 For the purpose of this standard, the pollution degree is of the micro-environment. [2.5.58 of IEC 947-1]

2.9.11 *Micro-environment (of a clearance or creepage distance)*

The ambient conditions which surround the clearance or creepage distance under consideration.

NOTE - The micro-environment of the creepage distance or clearance and not the environment of the ASSEMBLY or components determines the effect on the insulation. The micro-environment may be better or worse than the environment of the ASSEMBLY or components. It includes all factors influencing the insulation, such as climatic and electromagnetic conditions, generation of pollution, etc. [2.5.59 of IEC 947-1 modified]

2.9.12 *Overvoltage category (of a circuit or within an electrical system)*

A conventional number based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending upon the means employed to influence the overvoltages.

NOTE - In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements, such as an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category. [2.5.60 of IEC 947-1]

2.9.13 *Surge arrester*

A device designed to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently the amplitude of the follow-on current. [2.2.22 of IEC 947-1] [IEV 604-03-51]

2.9.14 *Co-ordination of insulation*

The correlation of insulating characteristics of electrical equipment with the expected overvoltages and the characteristics of overvoltage protective devices on the one hand, and with the expected micro-environment and the pollution protective means on the other hand. [2.5.61 of IEC 947-1] [IEV 604-03-08 modified]

2.9.15 *Homogeneous (uniform) field*

An electric field which has an essentially constant voltage gradient between electrodes, such as that between two spheres where the radius of each sphere is greater than the distance between them. [2.5.62 of IEC 947-1]

2.9.16 *Inhomogeneous (non-uniform) field*

An electric field which has not an essentially constant voltage gradient between electrodes. [2.5.63 of IEC 947-1]

2.9.17 *Tracking*

The progressive formation of conducting paths which are produced on the surface of a solid insulating material, due to the combined effects of electric stress and electrolytic contamination on this surface. [2.5.64 of IEC 947-1]

2.9.18 *Comparative tracking index (CTI)*

The numerical value of the maximum voltage in volts at which a material withstands 50 drops of a defined test liquid without tracking.

NOTE - The value of each test voltage and the CTI should be divisible by 25. [2.5.65 of IEC 947-1]

2.10 *Short-circuit currents*

2.10.1 *Short-circuit current (I_c) (of a circuit of an ASSEMBLY)*

An over-current resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit. [2.1.6 of IEC 947-1] [IEV 441-11-07 modified]

2.10.2 *Prospective short-circuit current (I_{cp}) (of a circuit of an ASSEMBLY)*

A current which flows when the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as possible to the supply terminal of the ASSEMBLY.

2.10.3 *Cut-off current; Let-through current*

The maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse. [IEV 441-17-12]

NOTE - This concept is of particular importance when the switching device or the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

3 Classification of ASSEMBLIES

ASSEMBLIES are classified according to:

- the external design (see 2.3);
- the place of installation (see 2.5.1 and 2.5.2);
- the conditions of installation with respect to mobility (see 2.5.3 and 2.5.4);
- the degree of protection (see 7.2.1);
- the type of enclosure;
- the method of mounting, for example fixed or removable parts (see 7.6.3 and 7.6.4);
- the measures for the protection of persons (see 7.4).
- the form of internal separation (see 7.7);
- the types of electrical connections of functional units (see 7.11).

4 Electrical characteristics of ASSEMBLIES

An ASSEMBLY is defined by the following electrical characteristics.

4.1 Rated voltages

An ASSEMBLY is defined by the following rated voltages of its various circuits:

4.1.1 Rated operational voltage (*of a circuit of an ASSEMBLY*)

A rated operational voltage (U_o) of a circuit of an ASSEMBLY is the value of voltage which, combined with the rated current of this circuit, determines its application.

For polyphase circuits, it is stated as the voltage between phases.

NOTE - Standard values of rated control circuit voltages are found in the relevant standards for the incorporated devices.

The manufacturer of the ASSEMBLY shall state the limits of voltage necessary for correct functioning of the main and auxiliary circuits. In any case, these limits must be such that the voltage at the control circuit terminals of incorporated components is maintained under normal load conditions, within the limits specified in the relevant IEC standards.

4.1.2 Rated insulation voltage (U_i) (*of a circuit of an ASSEMBLY*)

The rated insulation voltage (U_i) of a circuit of an ASSEMBLY is the voltage value to which dielectric test voltages and creepage distances are referred.

The maximum rated operational voltage of any circuit of the ASSEMBLY shall not exceed its rated insulation voltage. It is assumed that the operational voltage of any circuit of an ASSEMBLY will not, even temporarily, exceed 110 % of its rated insulation voltage.

NOTE - For single-phase circuits derived from IT systems (see IEC 364-3), the rated insulation voltage should be at least equal to the voltage between phases of the supply.

4.1.3 Rated impulse withstand voltage (U_{imp}) (*of a circuit of an ASSEMBLY*)

The peak value of an impulse voltage of prescribed form and polarity which the circuit of an ASSEMBLY is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

The rated impulse withstand voltage of a circuit of an ASSEMBLY shall be equal to or higher than the values stated for the transient overvoltages occurring in the system in which the ASSEMBLY is inserted.

NOTE - Preferred values of rated impulse withstand voltage are those given in table 13 (page 153).

4.2 Rated current (of a circuit of an ASSEMBLY)

The rated current of a circuit of an ASSEMBLY is stated by the manufacturer, taking into consideration the ratings of the components of the electrical equipment within the ASSEMBLY, their disposition and application. This current must be carried without the temperature-rise of its several parts exceeding the limits specified in 7.3 (table 3) when verified according to 8.2.1.

NOTE - Due to the complex factors determining the rated currents, no standard values can be given.

4.3 Rated short-time withstand current (I_{cw}) (of a circuit of an ASSEMBLY)

The rated short-time withstand current of a circuit of an ASSEMBLY is the r.m.s. value of short-time current assigned to that circuit by the manufacturer, which that circuit can carry without damage under the test conditions specified in 8.2.3. Unless otherwise stated by the manufacturer, the time is 1s. [IEV 441-17-17 modified]

For a.c. the value of the current is the r.m.s. value of the a.c. component and it is assumed that the highest peak value likely to occur does not exceed n times this r.m.s. value, the factor n being given in 7.5.3.

NOTES

1 If the time is shorter than 1 s, both the rated short-time withstand current and the time should be stated, for example 20 kA, 0,2 s.

2 The rated short-time withstand current can be either a prospective current when the tests are conducted at the rated operational voltage or an actual current when the tests are conducted at a lower voltage. This rating is identical to the rated prospective short-circuit current defined in the previous edition of this standard if the test is conducted at the rated maximum operational voltage.

4.4 Rated peak withstand current (I_{pk}) (of a circuit of an ASSEMBLY)

The rated peak withstand current of a circuit of an ASSEMBLY is the value of peak current, assigned to that circuit by the manufacturer, which that circuit can withstand satisfactorily under the test conditions specified in 8.2.3 (see also 7.5.3). [IEV 441-17-18 modified]

4.5 Rated conditional short-circuit current (I_{cc}) (of a circuit of an ASSEMBLY)

The rated conditional short-circuit current of a circuit of an ASSEMBLY is the value of prospective short-circuit current, stated by the manufacturer, which that circuit, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of the device under the test conditions specified in 8.2.3 (see also 7.5.2).

The details of the specified short-circuit protective device shall be stated by the manufacturer.

NOTES

- 1 For a.c., the rated conditional short-circuit current is expressed by the r.m.s. value of the a.c. component.
- 2 The short-circuit protective device may either form an integral part of the ASSEMBLY or be a separate unit.

4.6 Rated fused short-circuit current (I_{cf}) (of a circuit of an ASSEMBLY)

The rated fused short-circuit current of a circuit of an ASSEMBLY is the rated conditional short-circuit current when the short-circuit protective device is a fuse according to IEC 269. [IEV 441-17-21 modified]

4.7 Rated diversity factor

The rated diversity factor of an ASSEMBLY or a part of an ASSEMBLY having several main circuits (e.g. a section or sub-section) is the ratio of the maximum sum, at any one time, of the assumed currents of all the main circuits involved, to the sum of the rated currents of all the main circuits of the ASSEMBLY or the selected part of the ASSEMBLY.

When the manufacturer states a rated diversity factor, this factor shall be used for the temperature-rise test in accordance with 8.2.1.

NOTE - In the absence of information concerning the actual currents, the following conventional values may be used:

Table 1

Number of main circuits	Diversity factor
2 and 3	0,9
4 and 5	0,8
6 to 9 inclusive	0,7
10 (and above)	0,6

4.8 Rated frequency

The rated frequency of an ASSEMBLY is the value of frequency which designates it and to which the operating conditions are referred.

If the circuits of an ASSEMBLY are designed for different values of frequency, the rated frequency of each circuit shall be given.

NOTE - The frequency should be within the limits specified in the relevant IEC standards for the incorporated components. Unless otherwise stated by the manufacturer of the ASSEMBLY, the limits are assumed to be 98 % and 102 % of the rated frequency.

5 Information to be given regarding the ASSEMBLY

The following information shall be given by the manufacturer:

5.1 Nameplates

Each ASSEMBLY shall be provided with one or more plates, marked in a durable manner and located in a place such that they are visible and legible when the ASSEMBLY is installed.

Information specified under Items a) and b) shall be given on the nameplate.

Information from items c) to q), where applicable, shall be given either on the nameplates or in the technical documentation of the manufacturer.

a) The manufacturer's name or trade mark;

NOTE - The manufacturer is deemed to be the organization taking the responsibility for the completed ASSEMBLY.

b) type designation or identification number or other means of identification making it possible to obtain relevant information from the manufacturer;

c) IEC 439-1;

d) type of current (and frequency in the case of a.c.);

e) rated operational voltages (see 4.1.1);

f) rated insulation voltages (see 4.1.2);

- rated impulse withstand voltage, when declared by the manufacturer (see 4.1.3);

g) rated voltages of auxiliary circuits (if applicable);

h) limits of operation (see clause 4);

j) rated current of each circuit (if applicable; see 4.2);

k) short-circuit withstand strength (see 7.5.2);

l) degree of protection (see 7.2.1);

m) measures for protection of persons (see 7.4);

n) service conditions for indoor use, outdoor use or special use, if different from the usual service conditions as given in 6.1;

- pollution degree, when declared by the manufacturer (see 6.1.2.3);

o) types of system earthing for which the ASSEMBLY is designed;

p) dimensions (see figures C.3 and C.4 of annex C) (not applicable for PT TA) given preferably in the order of height, width (or length), depth;

q) weight (not applicable for PT TA).

r) form of internal separation (see 7.7);

s) types of electrical connections of functional units (see 7.11).

t) environment 1 or 2 (see 7.10.1)

5.2 Markings

Inside the ASSEMBLY, it shall be possible to identify individual circuits and their protective devices.

Where items of equipment of the ASSEMBLY are designated, the designations used shall be identical with those in the wiring diagrams which may be supplied together with the ASSEMBLY and shall be in accordance with IEC 750.

5.3 *Instructions for installation, operation and maintenance*

The manufacturer shall specify in his documents or catalogues the conditions, if any, for the installation, operation and maintenance of the ASSEMBLY and the equipment contained therein.

If necessary, the instructions for the transport, installation and operation of the ASSEMBLY shall indicate the measures that are of particular importance for the proper and correct installation, commissioning and operation of the ASSEMBLY.

Where necessary, the above-mentioned documents shall indicate the recommended extent and frequency of maintenance.

If the circuitry is not obvious from the physical arrangement of the apparatus installed, suitable information shall be supplied, for example wiring diagrams or tables.

6 Service conditions

6.1 *Normal service conditions*

ASSEMBLIES conforming to this standard are intended for use under the following service conditions.

NOTE - If components, for example relays, electronic equipment, are used which are not designed for these conditions, appropriate steps should be taken to ensure proper operation (see 7.6.2.4, second paragraph).

6.1.1 *Ambient air temperature*

6.1.1.1 *Ambient air temperature for indoor installations*

The ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C

The lower limit of the ambient air temperature is -5 °C.

6.1.1.2 *Ambient air temperature for outdoor installations*

The ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C.

The lower limit of the ambient air temperature is:

- 25 °C in a temperate climate, and
- 50 °C in an arctic climate.

NOTE - The use of ASSEMBLIES in an arctic climate may require a special agreement between manufacturer and user.

6.1.2 *Atmospheric conditions*

6.1.2.1 *Atmospheric conditions for indoor installations*

The air is clean and its relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities may be permitted at lower temperatures, for example 90 % at +20 °C. Care should be taken of moderate condensation which may occasionally occur due to variations in temperature.

6.1.2.2 *Atmospheric conditions for outdoor installations*

The relative humidity may temporarily be as high as 100 % at a maximum temperature of +25 °C.

6.1.2.3 *Pollution degree*

The pollution degree (see 2.9.10) refers to the environmental conditions for which the ASSEMBLY is intended.

For switching devices and components inside an enclosure, the pollution degree of the environmental conditions in the enclosure is applicable.

For the purpose of evaluating clearances and creepage distances, the following four degrees of pollution in the micro-environment are established (clearances and creepage distances according to the different pollution degrees are given in tables 14 and 16):

Pollution degree 1:

No pollution or only dry, non-conductive pollution occurs.

Pollution degree 2:

Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation may be expected.

Pollution degree 3:

Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.

Pollution degree 4:

The pollution generates persistent conductivity caused, for instance, by conductive dust or by rain or snow.

Standard pollution degree of industrial applications:

Unless otherwise stated, ASSEMBLIES for industrial applications are generally for use in a pollution degree 3 environment. However, other pollution degrees may be considered to apply, depending upon particular applications or the micro-environment

NOTE - The pollution degree of the micro-environment for the equipment may be influenced by installation in an enclosure.

6.1.3 *Altitude*

The altitude of the site of installation does not exceed 2 000 m (6 600 ft).

NOTE - For electronic equipment to be used at altitudes above 1 000 m it may be necessary to take into account the reduction of the dielectric strength and of the cooling effect of the air. Electronic equipment intended to operate in these conditions should be designed or used in accordance with an agreement between manufacturer and user.

6.2 *Special service conditions*

Where any of the following special service conditions exist, the applicable particular requirements shall be complied with or special agreements shall be made between user and manufacturer. The user shall inform the manufacturer if such exceptional service conditions exist.

Special service conditions are for example:

6.2.1 Values of temperature, relative humidity and/or altitude differing from those specified in 6.1.

6.2.2 Applications where variations in temperature and/or air pressure take place at such a speed that exceptional condensation is liable to occur inside the ASSEMBLY.

6.2.3 Heavy pollution of the air by dust, smoke, corrosive or radioactive particles, vapours or salt.

6.2.4 Exposure to strong electric or magnetic fields.

6.2.5 Exposure to extreme temperatures, for example radiation from sun or furnaces.

6.2.6 Attack by fungus or small creatures.

6.2.7 Installation in locations where fire or explosion hazards exist.

6.2.8 Exposure to heavy vibration and shocks.

6.2.9 Installation in such a manner that the current-carrying capacity or breaking capacity is affected, for example equipment built into machines or recessed into walls.

6.2.10 Consideration of appropriate remedies against conducted and radiated disturbances other than EMC.

Consideration of appropriate remedies against EMC disturbances in environments other than those described in 7.10.1.

6.3 *Conditions during transport, storage and erection*

6.3.1 A special agreement shall be made between user and manufacturer if the conditions during transport, storage and erection, for example, temperature and humidity conditions, differ from those defined in 6.1.

Unless otherwise specified, the following temperature range applies during transport and storage: between $-25\text{ }^{\circ}\text{C}$ and $+55\text{ }^{\circ}\text{C}$ and, for short periods not exceeding 24 h, up to $+70\text{ }^{\circ}\text{C}$.

Equipment subjected to these extreme temperatures without being operated, shall not undergo any irreversible damage and shall then operate normally in the specified conditions.

7 Design and construction

7.1 Mechanical design

7.1.1 General

The ASSEMBLIES shall be constructed only of materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity which are likely to be encountered in normal service.

Protection against corrosion shall be ensured by the use of suitable materials or by the application of equivalent protective coatings to the exposed surface, taking account of the intended conditions of use and maintenance.

All enclosures or partitions including locking means for doors, withdrawable parts etc., shall be of a mechanical strength sufficient to withstand the stresses to which they may be subjected in normal service.

The apparatus and circuits in the ASSEMBLY shall be so arranged as to facilitate their operation and maintenance and at the same time to ensure the necessary degree of safety.

For parts of an ASSEMBLY which are made of insulating materials, resistance to heat, fire and tracking (if applicable) shall be verified according to 8.2.8. The verification is not needed for parts which are tested according to their own specifications.

7.1.2 Clearances, creepage distances and isolating distances

7.1.2.1 Clearances and creepage distances

Apparatus forming part of the ASSEMBLY shall have distances complying with the requirements of their relevant specifications, and these shall be maintained during normal service conditions.

When arranging apparatus within the ASSEMBLY, the specified creepage distances and clearances or impulse withstand voltages shall be complied with, taking into account the relevant service conditions.

For bare live conductors and terminations (e.g. busbars, connections between apparatus, cable lugs), the creepage distances and the clearances or impulse withstand voltages shall at least comply with those specified for the apparatus with which they are directly associated.

In addition, abnormal conditions such as short-circuit shall not permanently reduce the clearances or dielectric strength between busbars and/or connections other than cables

below the values specified for the apparatus with which they are directly associated. See also 8.2.2.

For ASSEMBLIES tested according to 8.2.2.6 of this standard, minimum values are given in tables 14 and 16 and test voltages in 7.1.2.3.

7.1.2.2 *Isolation of withdrawable parts*

In the case of functional units being mounted on withdrawable parts, the isolation provided shall at least comply with the requirements in the relevant specification for disconnectors* with the equipment in new condition, taking account of the manufacturing tolerances and changes in dimensions due to wear.

7.1.2.3 *Dielectric properties*

When for a circuit or circuits of an ASSEMBLY a rated impulse withstand voltage is declared by the manufacturer, the requirements of 7.1.2.3.1 to 7.1.2.3.7 apply and the circuit(s) shall satisfy the dielectric tests and verifications specified in 8.2.2.6 and 8.2.2.7

In the other cases, the circuits of an ASSEMBLY shall satisfy the dielectric test specified in 8.2.2.2, 8.2.2.3, 8.2.2.4 and 8.2.2.5.

NOTE - It should be kept in mind, however, that in this case the requirements of insulation co-ordination cannot be verified.

The concept of insulation co-ordination based on an impulse voltage rating is preferred.

7.1.2.3.1 *General*

The following requirements are based on the principles of IEC 664-1 and provide the possibility of co-ordination of insulation of equipment with the conditions within the installation.

The circuit(s) of an ASSEMBLY shall be capable of withstanding the rated impulse withstand voltage (see 4.1.3) in accordance with the overvoltage category given in annex G or, where applicable, the corresponding a.c. or d.c. voltage given in table 13. The withstand voltage across the isolation distances of devices suitable for isolation or of withdrawable parts is given in table 15.

NOTE - The correlation between the nominal voltage of the supply system and the rated impulse withstand voltage of the circuit(s) of an ASSEMBLY is given in annex G.

The rated impulse withstand voltage for a given rated operational voltage shall not be less than that corresponding in annex G to the nominal voltage of the supply system of the circuit at the point where the ASSEMBLY is to be used, and the appropriate overvoltage category.

* See IEC 947-3.

7.1.2.3.2 Impulse withstand voltage of the main circuit

- a) Clearances from live parts to parts intended to be earthed and between poles shall withstand the test voltage given in table 13 appropriate to the rated impulse withstand voltage.
- b) Clearances across the open contacts for withdrawable parts in the isolated position shall withstand the test voltage given in table 15 appropriate to the rated impulse withstand voltage.
- c) Solid insulation of ASSEMBLIES associated with clearances a) and/or b) shall withstand the impulse voltages specified in a) and/or b), as applicable.

7.1.2.3.3 Impulse withstand voltages of auxiliary and control circuits

- a) Auxiliary and control circuits which operate directly from the main circuit at the rated operational voltage without any means for reduction of overvoltage shall comply with the requirements of items a) and c) of 7.1.2.3.2
- b) Auxiliary and control circuits which do not operate directly from the main circuit may have an overvoltage withstand capacity different from that of the main circuit. Clearances and associated solid insulation of such circuits - a.c. or d.c. - shall withstand the appropriate voltage in accordance with annex G.

7.1.2.3.4 Clearances

Clearances shall be sufficient to enable the circuits to withstand the test voltage, according to 7.1.2.3.2 and 7.1.2.3.3.

Clearances shall be higher than the values given in table 14, for case B - Homogeneous field.

A test is not required if the clearances, related to the rated impulse withstand voltage and pollution degree, are higher than the values given in table 14 for case A - Inhomogeneous field.

The method of measuring creepage distances is given in annex F.

7.1.2.3.5 Creepage distances

a) Dimensioning

For pollution degrees 1 and 2, creepage distances shall not be smaller than the associated clearances selected according to 7.1.2.3.4. For pollution degrees 3 and 4 the creepage distances shall not be less than the case A clearances to reduce the risk of disruptive discharge due to overvoltages, even if the clearances are smaller than the values for case A as permitted in 7.1.2.3.4.

The method of measuring creepage distances is given in annex F.

Creepage distances shall correspond to a pollution degree as specified in 6.1.2.3 and to the corresponding material group at the rated insulation (or working) voltage given in table 16.

Material groups are classified as follows, according to the range of values of the comparative tracking index (CTI) (see 2.9.18):

- Material group I $600 \leq \text{CTI}$
- Material group II $400 \leq \text{CTI} < 600$
- Material group IIIa $175 \leq \text{CTI} < 400$
- Material group IIIb $100 \leq \text{CTI} < 175$

NOTES

1 The CTI values refer to the values obtained in accordance with IEC 112, method A, for the insulating material used.

2 For inorganic insulating materials, for example glass or ceramics, which do not track, creepage distances need not be greater than their associated clearances. However, the risk of disruptive discharge should be considered.

b) *Use of ribs*

A creepage distance can be reduced to 0,8 of the value of table 16 by using ribs of minimum height of 2 mm, irrespective of the number of ribs. The minimum base of the rib is determined by mechanical requirements (see annex F, clause F.2).

c) *Special applications*

Circuits intended for certain applications where severe consequences of an insulation fault have to be taken into account shall have one or more of the influencing factors of table 16 (distances, insulating materials, pollution in the micro-environment) utilized in such a way as to achieve a higher insulation voltage than the rated insulation voltage given to the circuits according to table 16.

7.1.2.3.6 *Solid insulation*

Dimensioning rules for solid insulation are under consideration.

7.1.2.3.7 *Spacings between separate circuits*

For dimensioning clearances, creepage distances and solid insulation between separate circuits, the highest voltage ratings shall be used (rated impulse withstand voltage for clearances and associated solid insulation and rated insulation voltage for creepage distances).

7.1.3 *Terminals for external conductors*

7.1.3.1 The manufacturer shall indicate if the terminals are suitable for connection of copper or aluminium conductors or both. The terminals shall be such that the external conductors may be connected by a means (screws, connectors, etc.) which ensures that the necessary contact pressure corresponding to the current rating and the short-circuit strength of the apparatus and the circuit is maintained.

7.1.3.2 In the absence of a special agreement between manufacturer and user, terminals shall be capable of accommodating conductors and cables of copper from the smallest to the largest cross-sectional areas corresponding to the appropriate rated current (see annex A).

Where aluminium conductors are used, terminals which cater for the maximum sizes of conductors given in column c of table A.1 of annex A are usually dimensionally adequate. In those instances where the use of this maximum size of aluminium conductor prevents the full utilization of the rated current of the circuit, it will be necessary, subject to agreement between manufacturer and user, to provide means of connection for an aluminium conductor of the next larger size.

In the case where external conductors for electronic circuits with low level currents and voltages (less than 1 A and less than 50 V a.c. or 120 V d.c.) have to be connected to an ASSEMBLY, table A.1 of annex A does not apply (see note 2 of table A.1).

7.1.3.3 The available wiring space shall permit proper connection of the external conductors of the indicated material and, in the case of multicore cables, spreading of the cores.

The conductors must not be subjected to stresses which reduce their normal life.

7.1.3.4 Unless otherwise agreed between manufacturer and user, on three-phase and neutral circuits, terminals for the neutral conductor shall allow the connection of copper conductors having a current-carrying capacity:

- equal to half the current-carrying capacity of the phase conductor, with a minimum of 10 mm², if the size of the phase conductor exceeds 10 mm²;
- equal to the full current-carrying capacity of the phase conductor if the size of the latter is less than or equal to 10 mm².

NOTES

1 For conductors other than copper conductors, the above cross-sections should be replaced by cross-sections of equivalent conductivity, which may require larger terminals.

2 For certain applications in which the current in the neutral conductor may reach high values, for example large fluorescent lighting installations, a neutral conductor having the same current-carrying capacity as the phase conductors may be necessary, subject to special agreement between manufacturer and user.

7.1.3.5 If connecting facilities for incoming and outgoing neutral, protective and PEN conductors are provided, they shall be arranged in the vicinity of the associated phase conductor terminals.

7.1.3.6 Openings in cable entries, cover plates, etc., shall be so designed that when the cables are properly installed, the stated protective measures against contact and degree of protection shall be obtained. This implies the selection of means of entry suitable for the application as stated by the manufacturer.

7.1.3.7 Identification of terminals

Identification of terminals shall comply with IEC 445.

7.2 Enclosure and degree of protection

7.2.1 Degree of protection

7.2.1.1 The degree of protection provided by any ASSEMBLY against contact with live parts, ingress of solid foreign bodies and liquid is indicated by the designation IP... according to IEC 529.

For ASSEMBLIES for indoor use where there is no requirement for protection against ingress of water, the following IP references are preferred:

IP00, IP2X, IP3X, IP4X, IP5X.

Where some degree of protection against ingress of water is required, the following table gives the preferred IP numbers.

Table 2 - List of preferred IP numbers

First characteristic numeral Protection against contact and protection against ingress of solid foreign bodies	Second characteristic numeral Protection against harmful ingress of water				
	1	2	3	4	5
2	IP21				
3	IP31	IP32			
4		IP42	IP43		
5			IP53	IP54	IP55
6				IP64	IP65

7.2.1.2 The degree of protection of an enclosed assembly shall be at least IP2X, after installation in accordance with the manufacturer's instructions.

7.2.1.3 For ASSEMBLIES for outdoor use having no supplementary protection, the second characteristic numeral shall be at least 3.

NOTE - For outdoor installation, supplementary protection may be protective roofing or the like.

7.2.1.4 Unless otherwise specified, the degree of protection indicated by the manufacturer applies to the complete ASSEMBLY when installed in accordance with the manufacturer's instructions (see also 7.1.3.6), for example sealing of the open mounting surface of an ASSEMBLY, if necessary.

The manufacturer shall also state the degree(s) of protection against direct contact, ingress of solid foreign bodies and liquids under conditions necessitating the accessibility to internal parts of the ASSEMBLY in service by authorized personnel (see 7.4.6). For ASSEMBLIES with moveable and/or withdrawable parts see 7.6.4.3.

7.2.1.5 If the degree of protection of part of the ASSEMBLY, for example, on the operating face differs from that of the main portion, the manufacturer shall indicate the degree of protection of that part separately. Example: IP00, operating face IP20.

7.2.1.6 For PTTA, no IP codes can be given unless the appropriate verifications can be made according to IEC 529 or tested prefabricated enclosures are used.

7.2.2 Measures to take account of atmospheric humidity

In the case of an ASSEMBLY for outdoor installation and in the case of an enclosed ASSEMBLY for indoor installation intended for use in locations with high humidity and temperatures varying within wide limits, suitable arrangements (ventilation and/or internal heating, drain holes, etc.) shall be made to prevent harmful condensation within the ASSEMBLY. However, the specified degree of protection shall at the same time be maintained (for built-in apparatus, see 7.6.2.4).

7.3 Temperature rise

The temperature rise limits given in table 3 shall not be exceeded for ASSEMBLIES when verified in accordance with 8.2.1.

NOTE - The temperature rise of an element or part is the difference between the temperature of this element or part measured in accordance with 8.2.1.5 and the ambient air temperature outside the ASSEMBLY.