

Australian/New Zealand Standard™

Low-voltage switchgear and controlgear assemblies

Part 1: Type-tested and partially type-tested assemblies (IEC 60439-1:1999 MOD)



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Australian/New Zealand Standard™

Low-voltage switchgear and controlgear assemblies

Part 1: Type-tested and partially type-tested assemblies (IEC 60439-1:1999 MOD)

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-006, Industrial Switchgear and Controlgear to supersede AS 3439.1—1993, *Low-voltage switchgear and controlgear assemblies, Part 1: Type-tested and partially type-tested assemblies*.

The objective 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.

This Standard is a Part of a series:

AS/(NZS) 3439 Low-voltage switchgear and controlgear assemblies

AS/NZS 3439.1 Part 1: Type-tested and partially type-tested assemblies (this Standard)

AS/NZS 3439.2 Part 2: Particular requirements for busbar trunking systems (busways)

AS/NZS 3439.3 Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use—Distribution boards

AS 3439.4 Part 4: Particular requirements for assemblies for construction sites (ACS)

AS/NZS 3439.5 Part 5: Particular requirements for assemblies intended to be installed in public places—Cable distribution cabinets (CDCs) for power distribution in networks

This Standard is an adoption with national modifications and has been reproduced from, IEC 60439-1:1999, *Low-voltage switchgear and controlgear assemblies, Part 1: Type-tested and partially type-tested assemblies*, and has been varied as indicated to take account of Australian/New Zealand conditions.

Variations to IEC 60439-1:1999 are indicated at the appropriate places throughout this Standard. Strikethrough (~~example~~) identifies IEC tables, figures and passages of text which, for the purposes of this Australian/New Zealand Standard, are deleted. Where Australian/New Zealand tables, figures or passages of text are added, each is set in its proper place and identified by shading (**example**). Added figures are not themselves shaded, but are identified by a shaded border. These changes are identified in Annex ZZ for easy reference.

Additional information for Australian/New Zealand conditions is contained in Annexes ZA to ZF.

Differences between this Standard and AS 3439.1—1993 are listed in Annex ZG.

Information regarding the current carrying capacity of copper busbars can be found in AS 4388—1996.

This Standard provides requirements for stationary or moveable assemblies. Such assemblies consist of fixed, removable or withdrawable parts.

A separate class of assemblies, commonly known as demountable assemblies exists. These assemblies contain parts which can be removed but which may not comply with the minimum clearance requirements of removable or withdrawable parts as specified in this Standard.

Safety requirements for these assemblies are not necessarily covered in this Standard. Requirements for these assemblies are ‘under consideration’. It is the responsibility of the manufacturer to supply adequate information for the safe operation of these assemblies.

All type test approvals gained in accordance with AS 1136.1—1988 and AS 3439.1—1993 still remain valid.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text 'this standard' should read 'this Australian/New Zealand Standard'.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex to which they apply. A 'normative' annex is an integral part of a Standard, whereas an 'informative' annex is only for information and guidance.

CONTENTS

	<i>Page</i>
1 General.....	1
1.1 Scope and object	1
1.2 Normative references	1
2 Definitions.....	5
2.1 General.....	5
2.2 Constructional units of ASSEMBLIES	7
2.3 External design of ASSEMBLIES	8
2.4 Structural parts of ASSEMBLIES.....	9
2.5 Conditions of installation of ASSEMBLIES	11
2.6 Protective measures with regard to electric shock.....	12
2.7 Gangways within ASSEMBLIES	13
2.8 Electronic functions.....	13
2.9 Insulation co-ordination.....	13
2.10 Short-circuit currents.....	15
3 Classification of ASSEMBLIES	15
4 Electrical characteristics of ASSEMBLIES	16
4.1 Rated voltages.....	16
4.2 Rated current (I_n) (of a circuit of an ASSEMBLY).....	17
4.3 Rated short-time current (I_{cw}) (of a circuit of an ASSEMBLY)	17
4.4 Rated peak withstand current (I_{pk}) (of a circuit of an ASSEMBLY)	17
4.5 Rated conditional short-circuit current (I_{cc}) (of a circuit of an ASSEMBLY)	17
4.6 Rated fused short-circuit current (I_{cf}) (of a circuit of an ASSEMBLY)	17
4.7 Rated diversity factor	17
4.8 Rated frequency	18
5 Information to be given regarding the ASSEMBLY	18
5.1 Nameplates.....	18
5.2 Markings	19
5.3 Instructions for installation, operation and maintenance	19
6 Service conditions.....	20
6.1 Normal service conditions	20
6.2 Special service conditions.....	22
6.3 Conditions during transport, storage and erection	22
7 Design and construction.....	23
7.1 Mechanical design	23
7.2 Enclosure and degree of protection.....	27
7.3 Temperature rise	27
7.4 Protection against electric shock.....	28
7.5 Short-circuit protection and short-circuit withstand strength	37
7.6 Switching devices and components installed in ASSEMBLIES.....	40
7.7 Internal separation of ASSEMBLIES by barriers or partitions	45
7.8 Electrical connections inside an ASSEMBLY: bars and insulated conductors.....	48
7.9 Requirements for electronic equipment supply circuits	49
7.10 Electromagnetic compatibility (EMC).....	49

7.11	Description of the types of electrical connections of functional units.....	52
8	Test specifications	52
8.1	Classification of tests	52
8.2	Type tests	53
8.3	Routine tests.....	68
Annexes		
A	Minimum and maximum cross-sections of copper conductors suitable for connection (see 7.1.3.2)	73
B	Method of calculating the cross-sectional area of protective conductors with regard to thermal stresses due to currents of short duration (more detailed information is to be found in IEC 60364-5-54 AS/NZS 3000)	74
C	Typical examples of ASSEMBLIES.....	75
D	Forms of internal separations (see 7.7)	85
E	Items subject to agreement between manufacturer and user	88
F	Measurement of creepage distances and clearances	90
G	Correlation between the nominal voltage of the supply system and the rated impulse withstand voltage of the equipment	95
ZA	Information to be supplied by the purchaser when placing an enquiry or order	98
ZB	Types of system earthing	101
ZC	Guidelines for ASSEMBLIES intended to provide increased security against the occurrence or the effects of internal arcing faults	104
ZD	Internal arcing-fault tests	107
ZE	Selection of components	112
ZF	Examples of alternative methods of dividing ASSEMBLIES other than partitions or barriers (Metallic or non-metallic) (see 7.7)	114
ZG	Differences between this Standard and AS 3439.1—1993	120
ZZ	Variations to IEC 60439-1:1999 for application in Australia and New Zealand	124
Bibliography		97
Figures		
Figure 1	Ratio $\frac{\hat{U}_i + \Delta u}{\hat{U}_i}$ as a function of time	49
Figure 2	Maximum permitted harmonic component of the nominal system voltage.....	50
Figure C.1	Open-type ASSEMBLY (see 2.3.1)	75
Figure C.2	Dead-front ASSEMBLY (see 2.3.2)	76
Figure C.3	Cubicle-type ASSEMBLY (see 2.3.3.1)	77
Figure C.4	Multi-cubicle-type ASSEMBLY (see 2.3.3.2)	78
Figure C.5	Desk-type ASSEMBLY (see 2.3.3.3).....	79
Figure C.6	Multi-box-type ASSEMBLY (see 2.3.3.5).....	80
Figure C.7	Busbar trunking system (see 2.3.4)	81
Figure C.8	Mounting structure (see 2.4.2)	82
Figure C.9	Fixed parts (see 2.2.5, 2.4.3, 2.4.4)	83
Figure C.10	Withdrawable part (see 2.2.7)	84
Figure D.1	Symbols used in figures D.2.....	85
Figure D.2	Forms 1 and 2.....	86
Figure D.2	Forms 3 and 4.....	87
Figure F.1	Measurement of ribs.....	

Figure ZB1 – TN-S System.....	101
Figure ZB2 – TN-C-S System.....	102
Figure ZB3 – TN-C System	102
Figure ZB4 – TT System	103
Figure ZB5 – IT System	103
Figure ZF1(a) – General symbols	114
Figure ZF1(b) – Parts of functional units (See 2.1.5)	114
Figure ZF1(c) – Clarification regarding terminals for external conductors when IP2X rated functional unit housings are used to provide separation between functional units.....	115
Figure ZF2 – Form 2bi separation	115
Figure ZF3(a) – Form 3ah separation	116
Figure ZF3(b) – Form 3bh separation	116
Figure ZF3(c) – Form 3bi separation	117
Figure ZF3(d) – Form 3bih separation	117
Figure ZF4(a) – Form 4ah separation	118
Figure ZF4(b) – Form 4bh separation	118
Figure ZF4(c) – Form 4bi separation	119
Figure ZF4(d) – Form 4aih separation	119
Figure ZF4(e) – Form 4bih separation	119
Tables	
Table 1 – Values of rated diversity factor	18
Table 2 – Temperature-rise limits	28
Table 3 – Cross-sectional area of protective conductors (PE, PEN).....	33
Table 3A – Cross-sectional area of a copper bonding conductor	34
Table 4 – Standard values for the factor n	38
Table 5 – Conductor selection and installation requirements	40
Table 6 – Electrical conditions for the different positions of withdrawable parts	44
Table 6A – Forms of internal separation	46
Table 6B – Quick reference table showing criteria for typical forms of internal separation	47
Table 7 – List of verifications and tests to be performed on TTA and PTTA	54
Table 8 – Test copper conductors for test currents up to 400 A inclusive	56
Table 9 – Standard cross-sections of copper conductors corresponding to the test current ..	57
Table 10.....	59
Table 11.....	60
Table 12 – Relationship between prospective fault current and diameter of copper wire	63
Table 13 – Dielectric withstand voltages for impulse, power frequency and d.c tests	70
Table 14 – Minimum clearances in air	70
Table 15 – Test voltages across the open contacts of equipment suitable for isolation	71
Table 16 – Minimum creepage distances.....	72
Table A.1	73
Table B.1 – Values of k for insulated protective conductors not incorporated in cables, or bare protective conductors in contact with cable covering	74
Table G.1 – Correspondence between the nominal voltage of the supply system and the equipment rated impulse withstand voltage, in the case of overvoltage protection by surge-arresters according to IEC 60099-1	96

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Low-voltage switchgear and controlgear assemblies
Part 1: Type-tested and partially type-tested assemblies
(IEC 60439-1:1999 MOD)**

Any IEC table, figure or passage of text that is struck-through is not part of this Standard. Any Australian/New Zealand table, figure or passage of text that is added (and identified by shading) is part of this Standard.

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 will 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 the generation, transmission, distribution and conversion of electric energy, and for the control of electric energy consuming equipment.

It also applies to 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. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, 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. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

References to International Standards that are struck through in this Clause and subsequently in this Standard are replaced by references to equivalent Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is appropriately identified in this Clause.

~~IEC 60038:1983, IEC standard voltages~~

AS 60038, *Standard voltages*

~~IEC 60050(441):1984, International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses~~

AS 1852.441, *International Electrotechnical Vocabulary, Part 441: Switchgear, controlgear and fuses* (identical to IEC 60050(441):1984)

~~IEC 60050(471):1984, International Electrotechnical Vocabulary (IEV) — Chapter 471: Insulators~~

AS 1852.471, *International Electrotechnical Vocabulary, Part 471: Insulators* (identical to IEC 60050(471):1984)

~~IEC 60050(604):1987, International Electrotechnical Vocabulary (IEV) — Chapter 604: Generation, transmission and distribution of electricity—Operation~~

AS 1852.604, *International Electrotechnical Vocabulary, Part 604: Generation, transmission and distribution of electricity—Operation* (identical to IEC 60050(604):1987)

~~IEC 60050(826):1982, International Electrotechnical Vocabulary (IEV) — Chapter 826: Electrical installations of buildings~~

AS 1852.826, *International Electrotechnical Vocabulary, Part 826: Electrical installations of buildings* (identical to IEC 60050(826):1982)

~~IEC 60060, High-voltage test techniques~~

AS 1931, *High-voltage test techniques* (identical to IEC 60060)

~~IEC 60071-1:1976, Insulation co-ordination — Part 1: Terms, definitions, principles and rules~~

AS 1824.1, *Insulation co-ordination, Part 1: Definitions, principles and rules*

IEC 60073:1996, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indication devices and actuators*

IEC 60099-1:1991, *Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems*

~~IEC 60112:1979, Method for determining the comparative and the proof-tracking indices of solid insulating materials under moist conditions~~

AS/NZS 4695.112, *Fire hazard testing of electrotechnical products—Method for determining the comparative and the proof-tracking indices of solid insulating materials under moist conditions* (identical to IEC 60112:1979)

IEC 60146-2:1974, *Semiconductor convertors – Part 2: Semiconductor self-commutated convertors*

IEC 60227-3:1993, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60227-4:1992, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 4: Sheathed cables for fixed wiring*

IEC 60245-3:1994, *Rubber insulated cables of rated voltages up to and including 450/750 V – Part 3: Heat resistant silicone insulated cables*

IEC 60245-4:1994, *Rubber insulated cables of rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables*

~~IEC 60269, Low-voltage fuses~~

AS/NZS 60269, *Low-voltage fuses (identical to IEC 60269)*

~~IEC 60364-3:1993, Electrical installations of buildings – Part 3: Assessment of general characteristics~~

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60364-4-41:1992, Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock~~

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

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

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60364-4-46:1981, Electrical installations of buildings – Part 4: Protection for safety – Chapter 46: Isolation and switches~~

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

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

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60417 (all parts), Graphical symbols for use on equipment. Index, survey and compilation of the single sheets~~

AS 1104, *Informative symbols for use on electrical and electronic equipment (identical to IEC 60417 and IEC 60416)*

IEC 60445:1988, *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

IEC 60446:1989, *Identification of conductors by colours or numerals*

IEC 60447:1993, *Man-machine interface (MMI) – Actuating principles*

~~IEC 60502:1994, Extruded solid dielectric insulated power cables for rated voltages from 1 kV to 30 kV~~

AS/NZS 5000.1, *Electric cables—Polymeric insulated, Part 1: For working voltages up to and including 0.6/1 kV*

* There is a consolidated edition 2-1 (1999) that includes IEC 60364-4-443 (1995) and its amendment 1 (1999).

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

AS 1939, Degrees of protection provided by enclosures for electrical equipment (IP Code) (identical to IEC 60529:1989)

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

~~IEC 60750:1983, Item designation in electrotechnology~~

AS 3702, Item designation in electrotechnology

~~IEC 60865 (all parts), Short circuit currents – Calculation of effects~~

AS 3865, Calculation of the effects of short-circuit currents

~~IEC 60890:1987, A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear~~

AS 4388, A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear (identical to IEC 60890:1987)

~~IEC 60947-1:1988, Low-voltage switchgear and controlgear – Part 1: General rules~~

AS/NZS 3947.1, Low-voltage switchgear and controlgear, Part 1: General rules

~~IEC 60947-3:1999, Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units~~

AS/NZS 3947.3, Low-voltage switchgear and controlgear, Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units (identical to IEC 60947-3:1999 and includes its Amendment 1:2001)

~~IEC 60947-4-1:1990, Low-voltage switchgear and controlgear – Part 4: Contactors and motor-starters – Section 1: Electromechanical contactors and motor-starters~~

AS/NZS 3947.4.1, Low-voltage switchgear and controlgear, Part 4.1: Contactors and motor-starters—Electromechanical contactors and motor-starters

~~IEC 61000-3-6:1996, Electromagnetic compatibility (EMC) – Part 3: Limits – Section 6: Assessment of emission limits for distorting loads in MV and HV power systems~~

AS/NZS 61000.3.6, Electromagnetic compatibility (EMC), Part 3.6: Limits—Assessment of emission limits for distorting loads in MV and HV power systems

~~IEC 61000-3-7:1996, Electromagnetic compatibility (EMC) – Part 3: Limits – Section 7: Assessment of emission limits for fluctuating loads in MV and HV power systems~~

AS/NZS 61000.3.7, Electromagnetic compatibility (EMC), Part 3.7: Limits—Assessment of emission limits for fluctuating loads in MV and HV power systems

IEC 61000-4-2:1995, Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test – Basic EMC Publication

~~IEC 61000-4-3:1995, Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test~~

AS/NZS 61000.4.3, Electromagnetic compatibility (EMC), Part 4.3: Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test (identical to IEC 61000-4-3:1995)

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient burst immunity test* – Basic EMC Publication

~~IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity tests*~~

AS/NZS 61000.4.5, *Electromagnetic compatibility (EMC), Part 4.5: Testing and measurement techniques—Surge immunity test* (identical to IEC 61000-4-5:1995)

~~IEC 61117:1992, *A method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)*~~

AS 4278, *A method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)*

~~CISPR 11:1990, *Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment*~~

AS/NZS CISPR 11, *Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radiofrequency equipment.*

AS 2467, *Maintenance of electrical switchgear*

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 60050 (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 inter-connections and structural parts (see 2.4)

NOTE 1 Throughout this standard, the abbreviation ASSEMBLY is used for a low-voltage switchgear and controlgear ASSEMBLY.

NOTE 2 The components of the ASSEMBLY may be electromechanical or electronic.

NOTE 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

NOTE 1 Throughout this standard, the abbreviation TTA is used for a type-tested low-voltage switchgear and controlgear ASSEMBLY.

NOTE 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 tests.

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

NOTE Conductors which are connected to a functional unit but which are external to its compartment or enclosed protected space (e.g. auxiliary cables connected to a common compartment) are not considered to form part of the functional unit.

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 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)

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**transport unit**

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

2.2.5**fixed part** (see figure C.9)

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

2.2.6**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

2.2.7**withdrawable part** (see figure C.10)

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 The isolating distance may relate either to the main circuits only or to the main circuits and the auxiliary circuits (see 2.2.10), see also table 6.

2.2.8**connected position**

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

2.2.9**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.

2.2.10**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.

2.2.11**removed position**

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

2.2.12**electrical connections of functional units****2.2.12.1****fixed connection**

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

2.2.12.2**disconnectable connection**

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

2.2.12.3**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)

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)

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)

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)

a combination of a number of mechanically joined cubicles

2.3.3.3**desk-type ASSEMBLY** (see figure C.5)

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)

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)

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)

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)

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)

a structure not forming part of an ASSEMBLY designed to support an enclosed ASSEMBLY

2.4.3**mounting plate*** (see figure C.9)

a plate designed to support various components and suitable for installation in an ASSEMBLY

2.4.4**mounting frame*** (see figure C.9)

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

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

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

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

2.4.16

enclosed protected space

a part of an ASSEMBLY intended to enclose electrical components and which provides specified protection against external influences and contact with live parts

2.4.17

insertion interlock

a device preventing the introduction of a removable or withdrawable part into a fixed part not intended for that removable or withdrawable part

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 electro-magnetic 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 60947-1] [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 60947-1] [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 60947-1] [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 60947-1]

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 60947-1] [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 60947-1]

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 60947-1] [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 60060 and IEC 60071-1) [2.5.54.2 of IEC 60947-1]

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 60947-1]

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 60947-1] [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 60947-1]

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

NOTE 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.

NOTE 2 For the purpose of this standard, the pollution degree is of the micro-environment. [2.5.59 of IEC 60947-1]

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 60947-1 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 60947-1]

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 60947-1] [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 60947-1] [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 60947-1]

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 60947-1]

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 60947-1]

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 60947-1]

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 60947-1] [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 terminals 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)

The rated operational voltage (U_e) 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 rated 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 60364-3), 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 The preferred values of rated impulse withstand voltage are those given in table 13.

4.2 Rated current (I_n) (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 the various parts of the ASSEMBLY exceeding the limits specified in 7.3 (table 2) 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 current (I_{cw}) (of a circuit of an ASSEMBLY)

The rated short-time 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 1 s. [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.

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

NOTE 2 The rated short-time 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 second edition of this standard if the test is conducted at the maximum rated 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.

NOTE 1 For a.c., the rated conditional short-circuit current is expressed by the r.m.s. value of the a.c. component.

NOTE 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 60269. [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 – Values of rated diversity factor

Number of main circuits	Rated 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), b) and **u)** shall be given on the nameplate.

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

- a) 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 any other means of identification making it possible to obtain relevant information from the manufacturer;
- c) ~~IEC 60439-1~~ **AS/NZS 3439.1**;
- 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) given preferably in the order of height, width (or length), depth;
- q) weight;
- 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);
- u) date of manufacture.

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 60750.

Where access to live parts is required, the following symbolic electric shock risk sign shall be displayed in locations where additional attention is required to be given to the removal of covers and the like.



In addition, a DANGER sign as illustrated below, with an additional message of appropriate wording, should be conspicuously displayed on the enclosure of the ASSEMBLY to alert persons to the hazard.



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.

It is the responsibility of the owner of the ASSEMBLY to institute a system of maintenance. The manufacturer's recommendations should be addressed, together with the recommendations of AS 2467, in a planned preventative maintenance programme. This will minimize the risk of injury or breakdown and the consequent human suffering and/or loss of supply.

NOTE 1 Attention is drawn to AS 2467, which offers guidelines for the establishment of any proposed maintenance procedures.

NOTE 2 The operating temperature of unmarked PVC-insulated or elastomer-insulated cables is 75°C. This temperature must not be exceeded at any point where the insulation is relied upon.

If the temperature rise of the terminals, determined when the ASSEMBLY is tested at maximum rating as described in Clause 8.2.1, exceeds 50 K and if a circuit of the ASSEMBLY is to be loaded above 80% of its rated current, one of the following actions should be taken:

- separate the cable cores to provide electrical clearance for a minimum distance of 100 mm back from the terminals; or
- apply high temperature covering over the cores for 100 mm back from the terminals; or
- use a higher temperature grade cable of the same conductor cross-section as selected for V75 grade cable; or
- use a larger conductor.

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, and
- EMC disturbances in environments other than those described in 7.10.1.

6.2.101 Harmonics in the supply voltage exceed the limits specified in AS/NZS 61000.3.6.

6.2.102 Voltage fluctuations exceed the limits specified in AS/NZS 61000.3.7.

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°C and $+55^{\circ}\text{C}$ and, for short periods not exceeding 24 h, up to $+70^{\circ}\text{C}$.

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. This 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 distances 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 a 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 are given 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.

* See IEC 60947-3 AS/NZS 3947.3.

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 7.1.2.3.6 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 tests 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 60664-1 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.

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 circuits

- a) Auxiliary 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 circuits which do not operate directly from the main circuit may have an overvoltage withstand capacity different from that of the main circuit. The 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 at least as high as 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 clearances 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 $100 \leq \text{CTI} < 175$

NOTE 1 The CTI values refer to the values obtained in accordance with IEC 60112, method A, for the insulating material used.

NOTE 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 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 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 whether 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 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 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.

NOTE 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.

NOTE 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

It is recommended that identification of terminals should comply with IEC 60445.

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 60529~~ AS 1939.

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.

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 60529~~ AS 1939 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 2 apply for mean ambient air temperatures less than or equal to 35°C and 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.

Table 2 – Temperature-rise limits

Parts of ASSEMBLIES	Temperature rise K
Built-in components ¹⁾⁶⁾	In accordance with the relevant requirements for the individual components, if any, or, in accordance with the manufacturer's instructions, taking into consideration the temperature in the ASSEMBLY
Terminals for external insulated conductors	70 ²⁾
Busbars and conductors, plug-in contacts of removable or withdrawable parts which connect to busbars ⁶⁾	Limited by: – mechanical strength of conducting material; – possible effect on adjacent equipment; – permissible temperature limit of the insulating materials in contact with the conductor; – effect of the temperature of the conductor on the apparatus connected to it; – for plug-in contacts, nature and surface treatment of the contact material.
Manual operating means: – of metal – of insulating material	15 ³⁾ 25 ³⁾
Accessible external enclosures and covers: – metal surfaces – insulating surfaces	30 ⁴⁾ 40 ⁴⁾
Discrete arrangements of plug and socket-type connections	Determined by the limit for those components of the related equipment of which they form part ⁵⁾
1) The term 'built-in components' means: – conventional switchgear and controlgear; – electronic sub-ASSEMBLIES (e.g. rectifier bridge, printed circuit); – parts of the equipment (e.g. regulator, stabilized power supply unit, operational amplifier). 2) The temperature-rise limit of 70 K is a value based on the conventional test of 8.2.1. An ASSEMBLY used or tested under installation conditions may have connections, the type, nature and disposition of which will not be the same as those adopted for the test, and a different temperature rise of terminals may result and may be required or accepted. Where the terminals of the built-in component are also the terminals for external insulated conductors, the lower of the corresponding temperature-rise limits shall be applied. 3) Manual operating means within ASSEMBLIES which are only accessible after the ASSEMBLY has been opened, for example emergency handles, draw-out handles which are operated infrequently, are allowed to assume higher temperature rises. 4) Unless otherwise specified, in the case of covers and enclosures which are accessible but need not be touched during normal operation, an increase in the temperature-rise limits by 10 K is permissible. 5) This allows a degree of flexibility in respect of equipment (e.g. electronic devices) which is subject to temperature-rise limits different from those normally associated with switchgear and controlgear. 6) The requirements for built-in components, busbars and conductors, plug-in contacts of removable or withdrawable parts which connect to busbars, limited by: – mechanical strength of conducting material; – possible effect on adjacent equipment; – permissible temperature limit of the insulating materials in contact with the conductors; – the effect of the temperature of the conductor on the apparatus connected to it; and – for plug-in contacts, the nature and surface treatment of the contact material would generally be considered to be complied with if temperature rises do not exceed 70 K for H.C. copper busbars and 55 K for H.C. aluminium busbars. The temperature rise limits of 70 K and 55 K are based on maximum temperatures of 105°C and 90°C, respectively, under the normal service conditions according to Clause 6.1.	

7.4 Protection against electric shock

The following requirements are intended to ensure that the required protective measures are obtained when an ASSEMBLY is installed in a system conforming to the relevant specification.

For generally accepted protective measures refer to IEC 60364-4-41 AS/NZS 3000

Those protective measures which are of particular importance for an ASSEMBLY are reproduced in detail below, taking into account the specific needs of ASSEMBLIES.

7.4.1 Protection against both direct and indirect contact

7.4.1.1 Protection by safety extra-low voltage

(See clause 411.1 of IEC 60364-4-41 AS/NZS 3000.)

7.4.2 Protection against direct contact (see 2.6.8)

Protection against direct contact can be obtained either by appropriate constructional measures on the ASSEMBLY itself or by additional measures to be taken during installation; this may require information given by the manufacturer.

An example of additional measures to be taken is the installation of an open-type ASSEMBLY without further provisions in a location where access is only permitted for authorized personnel.

One or more of the protective measures defined below may be selected, taking into account the requirements laid down in the following sub-clauses. The choice of the protective measure shall be subject to an agreement between manufacturer and user.

NOTE Information given in the manufacturer's catalogues may take the place of such an agreement.

7.4.2.1 Protection by insulation of live parts

Live parts shall be completely covered with insulation which can only be removed by destruction or by use of a tool.

This insulation shall be made of suitable materials capable of durably withstanding the mechanical, electrical and thermal stresses to which the insulation may be subjected in service.

NOTE Examples are electrical components embedded in insulation, cables.

~~Paints, varnishes, lacquers and similar products alone are generally not considered to provide an adequate insulation for protection against electric shock in normal service.~~

This insulation shall not be inferior to cable insulation - 3.5 kV withstand, PVC cable hardness, suitable for maximum temperature obtained during the temperature rise test (Maximum allowed 105°C on busbars).

NOTES

- 1 The following is a partial list of known acceptable types of insulation:
 - PVC cable
 - polythene, PVC, pinhole free coating with minimum thickness 0.8 mm
 - solid extruded PVC tubing, 1.0 mm thick
 - high temperature heat shrink tubing with a minimum wall thickness of 0.45 mm after shrinkage
 - epoxy moulding
 - flame retardant PVC, polyester, polycarbonate sheet 1.6 mm thick
 - powder coating 0.3 mm minimum thickness
- 2 The following is a partial list of non-acceptable types of insulation:
 - paint, varnish or lacquer
 - tape
 - heat shrink tubing with a minimum wall thickness less than 0.45 mm after shrinkage
 - conductive powder coating.

7.4.2.2 Protection by barriers or enclosures

The following requirements shall be complied with.

7.4.2.2.1 All external surfaces shall conform to a degree of protection against direct contact of at least IP2X or IPXXB. The distance between the mechanical means provided for protection and the live parts they protect shall not be less than the values specified for the clearances and creepage distances in 7.1.2, unless the mechanical means are of insulating material.

7.4.2.2.2 All barriers and enclosures shall be firmly secured in place. Taking into account their nature, size and arrangement, they shall have sufficient stability and durability to resist the strains and stresses likely to occur in normal service without reducing the clearances according to 7.4.2.2.1.

7.4.2.2.3 Where it is necessary to make provision for the removal of barriers, opening of enclosures, or withdrawal of parts of enclosures (doors, casings, lids, covers and the like), this shall be in accordance with one of the following requirements.

- a) Removal, opening or withdrawal shall necessitate the use of a key or tool.
- b) All live parts which can unintentionally be touched after the door has been opened shall be disconnected before the door can be opened. In TN-C systems, the PEN conductor shall not be isolated or switched. In TN-S systems, the neutral conductor need not be isolated or switched (see ~~IEC 60364-4-46~~ AS/NZS 3000).

Example: By interlocking the door(s) with a disconnecter so that they can only be opened when the disconnecter is open and it shall not be possible to close the disconnecter while the door is open, except by overriding the interlock or using a tool.

If, for reasons of operation, the ASSEMBLY is fitted with a device permitting authorized persons to obtain access to live parts while the equipment is live, the interlock shall automatically be restored on reclosing the door(s).

- c) The ASSEMBLY shall include an internal obstacle or shutter shielding all live parts in such a manner that they cannot unintentionally be touched when the door is open. This obstacle or shutter shall meet the requirements of 7.4.2.2.1 (for exceptions, see item d)) and 7.4.2.2.2. It shall either be fixed in place or shall slide into place the moment the door is opened. It shall not be possible to remove this obstacle or shutter except by the use of a key or tool.

It may be necessary to provide warning labels.

Where the removal of a withdrawable unit exposes live parts, the provision of protection against direct contact with those parts shall be subject to agreement between the purchaser and the manufacturer.

- d) Where any parts behind a barrier or inside an enclosure need occasional handling (such as replacement of a lamp or of a fuse-link), the removal, opening or withdrawal without the use of a key or tool and without switching off shall be possible only if the following conditions are fulfilled (see 7.4.6):
 - an obstacle shall be provided behind the barrier or inside the enclosure so as to prevent persons from coming unintentionally into contact with live parts not protected by another protective measure. However, this obstacle need not prevent persons from coming intentionally into contact by by-passing this obstacle with the hand. It shall not be possible to remove the obstacle except through the use of a key or tool;
 - live parts, the voltage of which fulfils the conditions for the safety extra-low voltage, need not be covered.

7.4.2.3 Protection by obstacles

This measure applies to open-type ASSEMBLIES, see ~~clause 412.3 of IEC 60364-4-41~~ AS/NZS 3000).

7.4.3 Protection against indirect contact (see 2.6.9)

The user shall indicate the protective measure which is applied to the installation for which the ASSEMBLY is intended. In particular, attention is drawn to ~~IEC 60364-4-41~~ AS/NZS 3000, where requirements for protection against indirect contact are specified for the complete installation, for example the use of protective conductors.

7.4.3.1 Protection by using protective circuits

A protective circuit in an ASSEMBLY consists of either a separate protective conductor or the conductive structural parts, or both. It provides the following:

- protection against the consequences of faults within the ASSEMBLY;
- protection against the consequences of faults in external circuits supplied through the ASSEMBLY.

The requirements to be complied with are given in the following sub-clauses.

7.4.3.1.1 Constructional precautions shall be taken to ensure electrical continuity between the exposed conductive parts of the ASSEMBLY (see 7.4.3.1.5), and between these parts and the protective circuits of the installation (see 7.4.3.1.6).

For PTTA, unless a type-tested arrangement is used, or verification of the short-circuit strength is not necessary in accordance with 8.2.3.1.1 to 8.2.3.1.3, a separate protective conductor shall be used for the protective circuit and shall be so disposed with respect to the busbars that the effects of electromagnetic forces are negligible.

7.4.3.1.2 Certain exposed conductive parts of an ASSEMBLY which do not constitute a danger

- either because they cannot be touched on large surfaces or grasped with the hand,
- or because they are of small size (approximately 50 mm by 50 mm) or so located as to exclude any contact with live parts,

need not be connected to the protective circuits. This applies to screws, rivets and nameplates. It also applies to electromagnets of contactors or relays, magnetic cores of transformers (unless they are provided with a terminal for connection to the protective conductor), certain parts of releases, etc., irrespective of their size.

7.4.3.1.3 Manual operating means (handles, wheels, etc.) shall be

- either electrically connected, in a secure and permanent manner, with the parts connected to the protective circuits,
- or provided with additional insulation which insulates them from other conductive parts of the ASSEMBLY. This insulation shall be rated for at least the maximum rated insulation voltage of the associated device.

It is preferable that parts of manual operating means that are normally grasped by the hand during operation are made of or covered by insulating material rated for the maximum rated insulation voltage of the equipment.

7.4.3.1.4 Metal parts covered with a layer of varnish or enamel cannot generally be considered to be adequately insulated to comply with these requirements.

7.4.3.1.5 Continuity of protective circuits shall be ensured by effective interconnections either directly or by means of protective conductors.

- a) When a part of the ASSEMBLY is removed from the enclosure, for example for routine maintenance, the protective circuits for the remainder of the ASSEMBLY shall not be interrupted.

Means used for assembling the various metal parts of an ASSEMBLY are considered sufficient for ensuring continuity of the protective circuits if the precautions taken guarantee permanent good conductivity and a current-carrying capacity sufficient to withstand the earth fault current that may flow in the ASSEMBLY.

NOTE Flexible metal conduits should not be used as protective conductors.

- b) When removable or withdrawable parts are equipped with metal supporting surfaces, these surfaces are considered sufficient for ensuring continuity of the protective circuits provided that the pressure exerted on them is sufficiently high. Precautions may have to be taken to guarantee permanent good conductivity. The continuity of the protective circuit of a withdrawable part shall remain effective from the connected position to the disconnected position (isolated position) inclusively.
- c) For lids, doors, cover plates and the like, the usual metal screwed connections and metal hinges are considered sufficient to ensure continuity provided that no electrical equipment is attached to them.

If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lids, doors, cover plates, etc., steps shall be taken to ensure continuity of the protective circuits. It is recommended that these parts be fitted with a protective conductor (PE, PEN) whose cross-sectional area depends on the maximum cross-section of the supply lead to the equipment attached, and is in accordance with table 3A. An equivalent electrical connection especially designed for this purpose (sliding contact, hinges protected against corrosion) shall also be considered satisfactory.

- d) All parts of the protective circuit within the ASSEMBLY shall be so designed that they are capable of withstanding the highest thermal and dynamic stresses that may occur at the place of installation of the ASSEMBLY.
- e) When the enclosure of an ASSEMBLY is used as part of a protective circuit, the cross-sectional area of this enclosure shall be at least electrically equivalent to the minimum cross-sectional area specified in 7.4.3.1.7.
- f) Where continuity can be interrupted by means of connectors or plug-and-socket devices, the protective circuit shall be interrupted only after the live conductors have been interrupted and continuity shall be established before the live conductors are reconnected.
- g) In principle, with the exception of the cases mentioned under item f), protective circuits within an ASSEMBLY shall not include a disconnecting device (switch, disconnecter, etc.). The only means permitted in the run of protective conductors shall be links which are removable by means of a tool and accessible only to authorized personnel (these links may be required for certain tests).

7.4.3.1.6 The terminals for external protective conductors and sheathing shall, where required, be bare and, unless otherwise specified, suitable for the connection of copper conductors. A separate terminal of adequate size shall be provided for the outgoing protective conductor(s) of each circuit. In the case of enclosures and conductors of aluminium or aluminium alloys, particular consideration shall be given to the danger of electrolytic corrosion. In the case of ASSEMBLIES with conductive structures, enclosures, etc., means shall be provided to ensure electrical continuity between the exposed conductive parts (the protective circuit) of the ASSEMBLY and the metal sheathing of connecting cables (steel conduit, lead sheath, etc.). The connecting means to ensure the continuity of the exposed conductive parts with external protective conductors shall have no other function.

NOTE Special precautions may be necessary with metal parts of the ASSEMBLY, particularly gland plates, where abrasion resistant finishes, for example powder coatings, are used.

7.4.3.1.7 The cross-sectional area of protective conductors (PE, PEN) in an ASSEMBLY to which external conductors are intended to be connected shall be determined in one of the following ways.

- a) The cross-sectional area of the protective conductors (PE, PEN) shall be not less than the appropriate value shown in table 3. If table 3 will be applicable for PEN-conductors, it is assumed that neutral currents do not exceed 30% of the phase currents.

If the application of this table produces non-standard sizes, protective conductors (PE, PEN) having the nearest larger standard cross-sectional area are to be used.

Table 3 – Cross-sectional area of protective conductors (PE, PEN)

Cross-sectional area of phase conductors S mm ²	Minimum cross-sectional area of the corresponding protective conductor (PE, PEN) S_p mm ²
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S \leq 400$	$S/2$
$400 < S \leq 800$	200
$800 < S$	$S/4$

The values in table 3 are valid only if the protective conductor (PE, PEN) is made of the same metal as the phase conductors. If this is not so, the cross-sectional area of the protective conductor (PE, PEN) is to be determined in a manner which produces a conductance equivalent to that which results from the application of table 3.

For PEN conductors, the following additional requirements shall apply:

- the minimum cross-sectional area shall be 10 mm² Cu or 16 mm² Al;
 - the PEN conductors need not be insulated within an ASSEMBLY;
 - structural parts shall not be used as a PEN conductor. However, mounting rails made of copper or aluminium may be used as PEN conductors;
 - for certain applications in which the current in the PEN conductor may reach high values, for example large fluorescent lighting installations, a PEN conductor having the same or higher current-carrying capacity as the phase conductors may be necessary, subject to special agreement between manufacturer and user.
- b) The cross-sectional area of the protective conductor (PE, PEN) shall be calculated with the aid of the formula indicated in annex B or obtained by some other method, for example by testing.

For determining the cross-section of protective conductors (PE, PEN), the following conditions have to be satisfied simultaneously:

- 1) when the test according to 8.2.4.2 is carried out, the value of the fault-loop impedance shall fulfil the conditions required for the operation of the protective device;
- 2) the conditions of operation of the electrical protective device shall be so chosen as to eliminate the possibility of the fault current in the protective conductor (PE, PEN) causing a temperature rise that tends to impair this conductor or its electrical continuity.

7.4.3.1.8 In the case of an ASSEMBLY containing structural parts, frameworks, enclosures, etc., made of conducting material, a protective conductor, if provided, need not be insulated from these parts (for exceptions, see 7.4.3.1.9).

7.4.3.1.9 Conductors to certain protective devices including the conductors connecting them to a separate earth electrode shall be carefully insulated. This applies, for instance, to voltage-operated fault detection devices and can also apply to the earth-connection of the transformer neutral.

NOTE Attention is drawn to the special precautions to be taken in applying the requirements relating to such devices.

7.4.3.1.10 Accessible conductive parts of a device which cannot be connected to the protective circuit by the fixing means of the device shall be connected to the protective circuit of the ASSEMBLY for protective bonding by a conductor whose cross-sectional area is chosen according to table 3A.

Table 3A – Cross-sectional area of a copper bonding conductor

Rated operational current I_e A	Minimum cross-sectional area of a bonding conductor mm ²
$I_e \leq 20$	S*
$20 < I_e \leq 25$	2,5
$25 < I_e \leq 32$	4
$32 < I_e \leq 63$	6
$63 < I_e$	10
* S = cross-sectional area of the phase conductor (mm ²).	

7.4.3.2 Protection by measures other than using protective circuits

ASSEMBLIES can provide protection against indirect contact by means of the following measures which do not require a protective circuit:

- electrical separation of circuits;
- total insulation.

7.4.3.2.1 Electrical separation of circuits

(See ~~clause 413.5 of IEC 60364-4-41~~ AS/NZS 3000.)

7.4.3.2.2 Protection by total insulation*

For protection, by total insulation, against indirect contact, the following requirements shall be met.

- a) The apparatus shall be completely enclosed in insulating material. The enclosure shall carry the symbol  which shall be visible from the outside.
- b) The enclosure shall be made of an insulating material which is capable of withstanding the mechanical, electrical and thermal stresses to which it is liable to be subjected under normal or special service conditions (see 6.1 and 6.2) and it shall be resistant to ageing and flame-resistant.

* According to ~~clause 413.2.1.1 of IEC 60364-4-41~~ AS/NZS 3000, this is equivalent to Class II equipment.

- c) The enclosure shall at no point be pierced by conducting parts in such a manner that there is the possibility of a fault voltage being brought out of the enclosure.

This means that metal parts, such as actuator shafts which for constructional reasons have to be brought through the enclosure, shall be insulated on the inside or the outside of the enclosure from the live parts for the maximum rated insulation voltage and, if applicable, the maximum rated impulse withstand voltage of all circuits in the ASSEMBLY.

If an actuator is made of metal (whether covered by insulating material or not), it shall be provided with insulation rated for the maximum rated insulation voltage and, if applicable, the maximum impulse withstand voltage of all circuits in the ASSEMBLY.

If an actuator is principally made of insulating material, any of its metal parts which may become accessible in the event of insulation failure shall also be insulated from live parts for the maximum rated insulation voltage and, if applicable, the maximum rated impulse withstand voltage of all circuits in the ASSEMBLY.

- d) The enclosure, when the ASSEMBLY is ready for operation and connected to the supply, shall enclose all live parts, exposed conductive parts and parts belonging to a protective circuit in such a manner that they cannot be touched. The enclosure shall give at least the degree of protection IP3XD*.

If a protective conductor, which is extended to electrical equipment connected to the load side of the ASSEMBLY, is to be passed through an ASSEMBLY whose exposed conductive parts are insulated, the necessary terminals for connecting the external protective conductors shall be provided and identified by suitable marking.

Inside the enclosure, the protective conductor and its terminal shall be insulated from the live parts and the exposed conductive parts in the same way as the live parts are insulated.

- e) Exposed conductive parts within the ASSEMBLY shall not be connected to the protective circuit, i.e. they shall not be included in a protective measure involving the use of a protective circuit. This applies also to built-in apparatus, even if they have a connecting terminal for a protective conductor.
- f) If doors or covers of the enclosure can be opened without the use of a key or tool, an obstacle of insulating material shall be provided which will afford protection against unintentional contact not only with the accessible live parts, but also with the exposed conductive parts which are only accessible after the cover has been opened; this obstacle, however, shall not be removable except with the use of a tool.

7.4.4 Discharging of electrical charges

If the ASSEMBLY contains items of equipment which may retain dangerous electrical charges after they have been switched off (capacitors, etc.), a warning plate is required.

Small capacitors such as those used for arc extinction, for delaying the response of relays, etc., shall not be considered dangerous.

NOTE Unintentional contact is not considered dangerous if the voltages resulting from static charges fall below 120 V d.c in less than 5 s after disconnection from the power supply.

7.4.5 Operating and maintenance gangways within ASSEMBLIES (see 2.7.1 and 2.7.2)

Operating and maintenance gangways within an ASSEMBLY have to comply with the requirements of ~~IEC 60364-4-41~~ AS/NZS 3000.

NOTE Recesses within ASSEMBLIES of limited depth of the order of 1 m are not considered to be gangways.

7.4.6 Requirements related to accessibility in service by authorized personnel

For accessibility in service by authorized personnel, as agreed between manufacturer and user, one or more of the following requirements shall be fulfilled subject to agreement

* See IEC 60529 AS 1939.