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British Standard

Low-voltage switchgear and controlgear assemblies

Part 1. Specification for type-tested and partially type-tested assemblies (general requirements)

[IEC title : Low-voltage switchgear and controlgear assemblies

Part 1. Requirements for type-tested and partially type-tested assemblies]

Ensembles d'appareillage à basse tension

Partie 1. Règles générales pour les ensembles de série et les ensembles dérivés de série

Niederspannungs-Schaltgerätekombinationen

Teil 1. Allgemeine anforderungen an typgeprüfte und partiell typgeprüfte Kombinationen

National foreword

This revision of BS 5486 : Part 1, which has been prepared under the direction of the Power Electrical Engineering Standards Committee, is identical with IEC Publication 439-1 : 1985 'Low-voltage switchgear and controlgear assemblies. Part 1. Requirements for type-tested and partially type-tested assemblies', published by the International Electrotechnical Commission (IEC). It supersedes BS 5486 : Part 1 : 1977, which is identical with IEC 439 : 1973. BS 5486 : Part 1 : 1977 will be withdrawn once the remaining Parts of BS 5486, namely Parts 2, 11, 12 and 13, have been amended or revised, as necessary, to align them with this revision.

NOTE. Upon publication of this revision, the BSI Sales Department will respond to purchase orders for BS 5486 : Part 1 by supplying copies of the 1986 edition. Copies of the 1977 edition may be obtained by quoting this number 'BS 5486 : Part 1/77'.

This standard is a revision of the requirements for factory-built assemblies of switchgear and controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c.

The IEC intends to supplement IEC Publication 439-1 : 1985 by other publications in the same series, containing requirements for specific types of switchgear and controlgear assemblies; it is expected that these will be published as dual numbered Parts of BS 5486.

Terminology and conventions. The text of the IEC Publication has been accepted as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

In item (c) of 5.1, 'IEC Publication 439-1' should be read as 'BS 5486 : Part 1'.

Whenever page numbers are quoted in the text, they are IEC page numbers.

Cross-references. The references to the following four IEC Publications which form part of IEC Publication 364 'Electrical installation of buildings', should be replaced by references to 'Regulations for electrical installations', published by the Institution of Electrical Engineers.

- | | |
|-------------------|---|
| (a) IEC 364-3 | Part 3 Assessment of general characteristics |
| (b) IEC 364-4-41 | Part 4 Protection for safety
Chapter 41 Protection against electric shock |
| (c) IEC 364-5-537 | Part 5 Selection and erection of electrical equipment
Chapter 53 Switchgear and controlgear
Section 537 Devices for isolation and switching |
| (d) IEC 5-54 | Part 5 Selection and erection of electrical equipment
Chapter 54 Earthing arrangements and protective conductors |

In the first footnote to 7.4.3.2.2, reference is made to IEC Publication 536 for information on Class II equipment. This information is available in BS 2754 : 1976 'Memorandum. Construction of electrical equipment for protection against electric shock'.

International standard	Corresponding British Standard
IEC 73 : 1984	BS 4099 Colours of indicator lights, push-buttons, annunciators and digital readouts Part 1 : 1986 Specification for colours of indicator lights and push-buttons (Identical)
IEC 292-1 : 1969	BS 4941 Specification for voltages up to and including 1000 V a.c. and 1200 V d.c. Part 1 : 1979 Direct-on-line (full voltage) a.c. starters (Identical)
IEC 408 : 1972	BS 5419 : 1977 Specification for air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units for voltages up to and including 1000 V a.c. and 1200 V d.c. (Identical)
IEC 417 : 1973	BS 6217 : 1981 Guide to graphical symbols for use on electrical equipment (Identical)
IEC 445 : 1973	BS 5559 : 1978 Specification for identification of apparatus terminals and general rules for a uniform system of terminal marking, using an alphanumeric notation (Identical)
IEC 447 : 1974	BS 6013 : 1980 Specification for standard directions of movement for actuators which control the operation of electrical apparatus (Identical)
IEC 529 : 1976	BS 5490 : 1977 Specification for classification of degrees of protection provided by enclosures (Identical)
IEC 664 : 1980	PD 6499 : 1981 Guide to insulation co-ordination within low-voltage systems including clearances and creepage distances equipment (Identical)

The Technical Committee has reviewed the provisions of IEC Publications 146-2, 158-2 and 446, to which reference is made in the text, for information only, and has decided that they are acceptable for use in conjunction with this standard.

NOTE. Several requirements are referred to in this standard as 'under consideration'. These should be disregarded, as having no relevance to the application of the standard. As and when such requirements are agreed by the appropriate committee, they will be incorporated in this standard by amendment.

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

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British Standard

Low-voltage switchgear and controlgear assemblies

Part 1. Specification for type-tested and partially type-tested assemblies (general requirements)

1. General

1.1 Scope

This 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.

Note. — For higher frequencies, special considerations may be necessary.

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

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

Note. — Additional requirements for certain specific types of assemblies are given in supplementary standards.

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

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

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

1.2 Object

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.

2. Definitions

For the purpose of this standard, the following definitions apply.

2.1 General definitions

2.1.1 LV switchgear and controlgear assembly (hereinafter called "ASSEMBLY")

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

Notes 1. — The components of the ASSEMBLY may be electromechanical or electronic.

2. — For various reasons, for example transport or production, certain steps of assembly may be made in a place outside the factory of the manufacturer.

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

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

Notes 1. — Throughout this standard, the abbreviation TTA is used for type-tested low-voltage switchgear and controlgear assembly.

2. — For various reasons, for example transport or production, certain steps of assembly may be made in a place outside the factory of the manufacturer of the type-tested ASSEMBLY. Such an ASSEMBLY is considered as a type-tested ASSEMBLY provided the assembly is performed in accordance with the manufacturer's instructions in such a manner that compliance of the established type or system with this standard is assured, including submission to applicable routine test.

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

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

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.

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.

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.

2.1.5 *Functional unit*

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

2.1.6 *Incoming unit*

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

2.1.7 *Outgoing unit*

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

2.1.8 *Functional group*

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

2.1.9 *Test situation*

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

2.2 *Definitions concerning constructional units of ASSEMBLIES*

2.2.1 *Section (see Figure C4, page 109)*

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

2.2.2 *Sub-section*

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

2.2.3 *Compartment*

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

2.2.4 *Barriered section or sub-section*

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

2.2.5 *Transport unit*

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

2.2.6 *Fixed part (see Figure C9, page 114)*

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

2.2.7 *Removable part*

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

2.2.8 *Withdrawable part (see Figure C10, page 115)*

A removable part which can be moved to a position where an isolating distance (see Sub-clause 7.1.2.2) is established, whilst remaining mechanically attached to the ASSEMBLY.

Note. — This isolating distance may relate either to the main circuits only or to the main circuits and the auxiliary circuits (see Sub-clause 2.2.11), see also Table VI.

2.2.9 *Connected position*

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

2.2.10 *Test position*

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

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

2.2.11 *Disconnected position (isolated position)*

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

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

2.2.12 *Removed position*

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

2.3 *Definitions concerning the external design of ASSEMBLIES*

2.3.1 *Open-type ASSEMBLY (see Figure C1, page 106)*

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 C2, page 107)*

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 C3, page 108)*

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 C4, page 109)*

A combination of a number of mechanically joined cubicles.

2.3.3.3 *Desk-type ASSEMBLY (see Figure C5, page 110)*

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 C6, page 111)*

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

2.3.3.5 *Multi-box-type ASSEMBLY (see Figure C6, page 111)*

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 C7, page 112)*

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.

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 *Definitions concerning the structural parts of ASSEMBLIES*

2.4.1 *Supporting structure (see Figure C1, page 106)*

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 C8, page 113)*

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

2.4.3 *Mounting panel* (see Figure C9, page 114)*

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

2.4.4 *Mounting frame* (see Figure C9)*

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

2.4.5 *Enclosure*

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

2.4.6 *Cover*

A part of the external enclosure of an ASSEMBLY.

2.4.7 *Door*

A hinged or sliding cover.

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

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 Sub-clause 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.

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.

2.5 *Definitions concerning the 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 Sub-clause 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 Sub-clause 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 Definitions concerning 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.

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.

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.

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.

2.6.5 PEN conductor

An earthed conductor combining the functions of both protective conductor and neutral conductor.

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 Definitions relating to electronic functions

2.8.1 Screening

Enclosures used to protect conductors or equipment against interference caused in particular by electromagnetic radiation from other conductors or equipment.

3. Classification of ASSEMBLIES

ASSEMBLIES are classified according to:

- the external design (see Sub-clause 2.3);
- the place of installation (see Sub-clauses 2.5.1 and 2.5.2);
- the conditions of installation with respect to mobility (see Sub-clauses 2.5.3 and 2.5.4);
- the degree of protection (see Sub-clause 7.2.1);
- the type of enclosure;
- the method of mounting, for example fixed or removable parts (see Sub-clauses 7.6.3 and 7.6.4);
- the measures for the protection of persons (see Sub-clause 7.4).

4. Electrical characteristics of ASSEMBLIES

4.1 Rated voltages

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

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

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

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

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

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

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

The rated insulation voltage (U_i) of a circuit of an ASSEMBLY is the value of voltage which designates it and to which dielectric tests, clearances and creepage distances are referred.

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

Notes 1. — Standard values for rated insulation voltages for main circuits are under consideration.

2. — For single-phase circuits derived from IT systems (see IEC Publication 364-3: Electrical Installations of Buildings, Part 3: Assessment of General Characteristics), the insulation voltage should be at least equal to the voltage between phases of the supply.

4.2 *Rated current (of a circuit of an ASSEMBLY)*

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

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

4.3 *Rated short-time withstand current (of a circuit of an ASSEMBLY)*

The rated short-time withstand current of a circuit of an ASSEMBLY is the r.m.s. value of current that this circuit can carry during a specified short time under the test conditions specified in Sub-clause 8.2.3. Unless otherwise specified, the time is 1 s.

Note. — If the time is shorter than 1 s, both the rated short-time withstand current and the time should be stated, for example 20 kA, 0.2 s.

4.4 *Rated peak withstand current (of a circuit of an ASSEMBLY)*

The rated peak withstand current of a circuit of an ASSEMBLY is the value of peak current that this circuit can withstand under the test conditions specified in Sub-clause 8.2.3 (see also Sub-clause 7.5.3).

4.5 *Rated prospective short-circuit withstand current (of a circuit of an ASSEMBLY)*

The rated prospective short-circuit withstand current of a circuit of an ASSEMBLY is the r.m.s. value of prospective short-circuit current that this circuit can withstand during a specified time under the test conditions specified in Sub-clause 8.2.3; unless otherwise specified, this time is 1 s.

4.6 *Rated conditional short-circuit current (of a circuit of an ASSEMBLY)*

The rated conditional short-circuit current of a circuit of an ASSEMBLY is the value of the prospective current that this circuit, protected by a current limiting switching device, can withstand for the operating time of this device under the test conditions specified in Sub-clause 8.2.3 (see also Sub-clause 7.5.2).

Note. — For a.c., the value of current is the r.m.s. value of the a.c. component of the current.

4.7 *Rated fused short-circuit current (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 current-limiting switching device is a fuse.

4.8 *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 Sub-clause 8.2.1.

Note. — In the absence of information concerning the actual currents, the following conventional values may be used:

TABLE I

Number of main circuits	Diversity factor
2 and 3	0.9
4 and 5	0.8
6 to 9 inclusive	0.7
10 (and above)	0.6

Unless otherwise specified, for PTTA the diversity factor is 1.0.

4.9 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; such information which is not given on the nameplates shall be provided in some other appropriate way.

5.1 Nameplates

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

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

Information from Items *c)* to *q)* may, where applicable, be given on the nameplates, in the relevant documents, the circuit diagrams or in the manufacturer's list or catalogues.

a) The manufacturer's name or trade mark;

Note. — The final assembler of the ASSEMBLY is deemed to be its manufacturer (see Note 2 of Sub-clause 2.1.1).

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

c) IEC Publication 439-1;

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

e) rated operational voltages (see Sub-clause 4.1.1);

f) rated insulation voltages (see Sub-clause 4.1.2);

- g) rated voltages of auxiliary circuits (if applicable);
- h) limits of operation (see Clause 4);
- i) rated current of each circuit (if applicable; see Sub-clause 4.2);
- k) short-circuit strength (see Sub-clause 7.5.2);
- l) degree of protection (see Sub-clause 7.2.1);
- m) measures for protection of persons (see Sub-clause 7.4);
- n) service conditions for indoor use, outdoor use or special use, if different from the usual service conditions as given in Sub-clause 6.1;
- o) types of system earthing for which the ASSEMBLY is designed;
- p) dimensions (see Figures C3 and C4, pages 108 and 109) given preferably in the order of height, width (or length), depth (not applicable for PTTA);
- q) weight (not applicable for PTTA).

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.

5.3 Instructions for installation, operation and maintenance

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

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

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

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

6. Service conditions

6.1 Normal service conditions

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

Note. — If components, for example relays, electronic equipment, are used which are not designed for these conditions, appropriate steps should be taken to ensure proper operation (see Sub-clause 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 $+40^{\circ}\text{C}$ and its average over a period of 24 h does not exceed $+35^{\circ}\text{C}$.

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 $+40^{\circ}\text{C}$ and its average over a period of 24 h does not exceed $+35^{\circ}\text{C}$.

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 $+40^{\circ}\text{C}$. Higher relative humidities may be permitted at lower temperatures, for example 90% at $+20^{\circ}\text{C}$. 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 $+25^{\circ}\text{C}$.

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 (3 300 ft) 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 Sub-clause 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 electrical and radiated interferences, shall be the subject of agreement between manufacturer and user.

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 Sub-clause 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 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.

7.1.2 *Clearances, creepage distances and isolating distances**

7.1.2.1 *Clearances and creepage distances*

The apparatus forming part of the ASSEMBLY shall have distances complying with those specified in their relevant specifications, and these shall be maintained during normal service conditions.

When arranging the apparatus within the ASSEMBLY, the clearances and creepage distances specified for them 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 clearances and creepage distances shall at least comply with those specified for the apparatus with which they are immediately associated.

In addition, abnormal conditions such as short-circuit shall not permanently reduce the distances between busbars and/or connections other than cables below the values specified for the apparatus with which they are immediately associated. See also Sub-clause 8.2.2.2.

* Application of the data given in IEC Publication 664: Insulation Co-ordination within Low-voltage Systems Including Clearances and Creepage Distances for Equipment, to switchgear and controlgear assemblies is under consideration. This may also affect Clauses 4, 5 and 8.

7.1.2.2 *Isolating distances*

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

7.1.3 *Terminals for external conductors*

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

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

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

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

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 16 mm², if the size of the phase conductor exceeds 16 mm²,
- equal to the full current-carrying capacity of the phase conductor if the size of the latter is less than or equal to 16 mm².

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

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

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

*IEC Publication 408: Low-voltage Air-break Disconnectors, Air-break Switch-disconnectors and Fuse-combination Units.

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

7.1.3.7 Identification of terminals

Identification of terminals shall comply with IEC Publication 445: Identification of Apparatus Terminals and General Rules for a Uniform System of Terminal Marking, Using an Alphanumeric Notation.

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 Publication 529: Classification of Degrees of Protection Provided by Enclosures.

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

IP00, IP2X, IP3X, IP4X, IP5X.

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

TABLE II
List of preferred IP numbers

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

7.2.1.2 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.

7.2.1.3 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 Sub-clause 7.1.3.6), for example sealing of the open mounting surface of an ASSEMBLY, if necessary.

7.2.1.4 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.

- 7.2.1.5 For PTTA, no IP number(s) can be given unless the appropriate tests can be made, or the degree(s) of protection can be checked by inspection according to IEC Publication 529, or tested prefabricated enclosures are used.

7.2.2 Measures to take account of atmospheric humidity

In the case of an ASSEMBLY for outdoor installation and in the case of an enclosed ASSEMBLY for indoor installation intended for use in locations with high humidity and temperatures varying within wide limits, suitable arrangements (ventilation and/or internal heating, 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 Sub-clause 7.6.2.4).

7.3 Temperature rise

The temperature rise limits given in Table III shall not be exceeded for ASSEMBLIES when verified in accordance with Sub-clause 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 Sub-clause 8.2.1.5 and the ambient air temperature outside the ASSEMBLY.

TABLE III
Temperature rise limits

Parts of ASSEMBLIES	Temperature rise (K)
Built-in components ¹⁾	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	Limited by: — mechanical strength of conducting material; — possible effect on adjacent equipment; — permissible temperature limit of the insulating materials in contact with the conductor; — the 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 connection	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 Sub-clause 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.

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.

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 Publication 364-4-41: Electrical Installations of Buildings, Part 4: Protection for Safety, Chapter 41: Protection against Electric Shock.

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 IEC Publication 364-4-41, Clause 411.1.

7.4.2 *Protection against direct contact (see Sub-clause 2.6.7)*

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.

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

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 of at least IP2X. The distance between the mechanical means provided for protection and the live parts they protect shall be not less than the values specified for the clearances and creepage distances in Sub-clause 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 Sub-clause 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.

Example: By interlocking the door or doors with a disconnect so that they can only be opened when the disconnect is open and it shall not be possible to close the disconnect 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 or doors.

- 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 Sub-clauses 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.

- d) Where any parts behind a barrier or 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:

- An obstacle shall be provided inside the barrier or 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 IEC Publication 364-4-41, Clause 412.3.

7.4.3 Protection against indirect contact (see Sub-clause 2.6.8)

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 Publication 364-4-41, 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: