

INTERNATIONAL STANDARD

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**High-voltage switchgear and controlgear –
Part 201: AC solid-insulation enclosed switchgear and controlgear for rated
voltages above 1 kV and up to and including 52 kV**

**Appareillage à haute tension –
Partie 201: Appareillage sous enveloppe isolante solide pour courant alternatif
de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 201: AC solid-insulation enclosed switchgear
and controlgear for rated voltages above 1 kV
and up to and including 52 kV**

FOREWORD

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International Standard IEC 62271-201 has been prepared by subcommittee 17C: High-voltage switchgear and controlgear assemblies, of IEC technical committee 17: Switchgear and controlgear.

This second edition cancels and replaces the first edition, published in 2006. This edition constitutes a technical revision.

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

- a) apart from updating with the second edition of IEC 62271-200 (issued in 2011), definitions, classifications and testing procedures have been specified more precisely;
- b) access to the solid-insulation enclosed switchgear and controlgear is now restricted to authorized personnel only. This implies that “accessibility class B” (public access) has been deleted throughout the document;

- c) the term “protection category” has been introduced to replace the term “protection grade” (PA, PB1 and PB2)

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

FDIS	Report on voting
17C/594/FDIS	17C/597/RVD

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

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

This standard should be read in conjunction with IEC 62271-1:2007 and its Amendment 1:2011, to which it refers and which is applicable, unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1. Amendments to these clauses and subclauses are given under the same numbering, whilst additional subclauses are numbered from 101.

The reader's attention is drawn to the fact that Annex CC lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

1 General

1.1 Scope

This part of IEC 62271 specifies requirements for prefabricated solid-insulation enclosed switchgear and controlgear for alternating current of rated voltages above 1 kV and up to and including 52 kV for indoor installation and for service frequencies up to and including 60 Hz.

Access to the switchgear and controlgear is restricted to authorized personnel.

NOTE 1 For the use of this document high-voltage (IEC 60050-601:1985, 601-01-27) is the rated voltage above 1 000 V. However, medium voltage (IEC 60050-601:1985, 601-01-28) is commonly used for distribution systems with voltages above 1 kV and generally applied up to and including 52 kV; refer to [1] of Bibliography.

NOTE 2 Although primarily dedicated to three-phase systems, this standard can also be applied to single-phase or two-phase systems.

Enclosures may include fixed and removable components and may be filled with fluid (liquid or gas) to provide an extra insulation. For switchgear and controlgear containing gas-filled compartments, the design pressure is limited to a maximum of 300 kPa (relative pressure).

Solid-insulation enclosed switchgear and controlgear complying with this standard can be safely touched when energised.

Solid-insulation enclosed switchgear and controlgear for special use, for example, in flammable atmospheres, in mines or on board ships, may be subject to additional requirements.

Components contained in solid-insulation enclosed switchgear and controlgear are designed and tested in accordance with their various relevant standards. This standard supplements the standards for the individual components regarding their installation in switchgear and controlgear assemblies.

This standard does not preclude that other equipment may be included in the same enclosure. In such a case, any possible influence of that equipment on the switchgear and controlgear should be taken into account.

NOTE 3 Switchgear and controlgear assemblies having a metal enclosure are covered by IEC 62271-200 refer to [9] of Bibliography.

1.2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

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

IEC 62262:2002, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62271-1:2007, *High-voltage switchgear and controlgear – Part 1: Common specifications*
Amendment 1:2011

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-102:2001, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*
Amendment 1:2011
Amendment 2:2013

IEC 62271-103:2011, *High-voltage switchgear and controlgear – Part 103: Switches for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-105:2012, *High-voltage switchgear and controlgear – Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-106:2011, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

ISO/IEC Guide 51:1999, *Safety aspects – Guidelines for their inclusion in standards*

2 Normal and special service conditions

Clause 2 of IEC 62271-1:2007 is applicable with the following addition:

Unless otherwise specified in this standard, the solid-insulation enclosed switchgear and controlgear is designed to be used under normal indoor service conditions.

Solid-insulation enclosed switchgear and controlgear, under the scope of IEC/TS 62271-304 and intended to be used in service conditions more severe with respect to condensation and pollution than the normal service conditions specified in this standard, may be classified with a "Design Class" 1 or 2 according to IEC/TS 62271-304 to demonstrate its ability to withstand such severe conditions.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-151, IEC 60050-441 and IEC 62271-1 as well as the following apply.

NOTE Additional definitions are classified so as to be aligned with the classification system used in IEC 60050-441.

3.101**switchgear and controlgear**

general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:1984, 441-11-01]

3.102**assembly** (of switchgear and controlgear)

combination of switchgear and/or controlgear completely assembled with all internal electrical and mechanical interconnections

[SOURCE: IEC 60050-441:1984, 441-12-01]

3.103**solid-insulation enclosed switchgear and controlgear**

switchgear and controlgear assemblies with an external solid insulating enclosure and completely assembled, except for external connections

Note 1 to entry: The external insulation may be supplied with a (semi-)conducting layer.

[SOURCE: IEC 60050-441:1984, 441-12-06, modified – modification of the wording]

3.104**functional unit** (of an assembly)

part of solid-insulation enclosed switchgear and controlgear comprising all the components of the main circuits and auxiliary circuits that contribute to the fulfilment of a single function

Note 1 to entry: Functional units may be distinguished according to the function for which they are intended, for example, incoming unit, outgoing unit, etc.

[SOURCE: IEC 60050-441:1984, 441-13-04, modified – modification of the wording]

3.105**multi-tier design**

design of metal-enclosed switchgear in which the main switching devices of two or more functional units are arranged vertically (one above the other) within a common enclosure

3.106**transport unit**

part of solid-insulation enclosed switchgear and controlgear suitable for shipment without being dismantled

3.107**solid insulating enclosure**

part of solid-insulation enclosed switchgear and controlgear providing a specified degree of protection of equipment against external influences and a specified degree of protection against electric shock by limiting the approach to or contact with live parts and against contact with moving parts

Note 1 to entry: The main part of the enclosure is of solid insulating material, and may have added (semi-)conductive layers.

Note 2 to entry: If the resistance of the enclosure of the switchgear and controlgear to the earthing point provided is everywhere less than, or equal to, 100 mΩ, IEC 62271-200 is applicable.

[SOURCE: IEC 60050-441:1984, 441-13-01, modified – modification of the wording]

3.108

high-voltage compartment

compartment of solid-insulation enclosed switchgear and controlgear containing high-voltage conducting parts, enclosed except for openings necessary for interconnection, control or ventilation.

Note 1 to entry: General definition of "compartment" is provided by IEC 60050-441:1984, 441-13-05, as "a part of an assembly enclosed except for openings necessary for interconnection, control or ventilation".

Note 2 to entry: A compartment may contain barriers, structures or components that are intended to provide various functions, such as mechanical or dielectrical, but not to function as a partition or enclosure.

Note 3 to entry: High-voltage compartments are identified according to the main component(s) contained therein (refer to 5.103.1).

Note 4 to entry: Four types of high-voltage compartments are distinguished, three that can be opened, called accessible (see 3.108.1 to 3.108.3) and one that cannot be opened, called non-accessible (see 3.108.4)

3.108.1

interlock-controlled accessible compartment

high-voltage compartment, intended to be opened for normal operation and/or normal maintenance as stated by the manufacturer, in which access is controlled by integral design of the switchgear and controlgear

Note 1 to entry: Installation, extension, repairing, etc. are not considered as normal maintenance.

3.108.2

procedure-based accessible compartment

high-voltage compartment, intended to be opened for normal operation and/or normal maintenance as stated by the manufacturer, in which access is controlled by a suitable procedure combined with locking

Note 1 to entry: Installation, extension, repairing, etc. are not considered as normal maintenance.

3.108.3

tool-based accessible compartment

high-voltage compartment that may be opened only through the use of tools, but not intended for opening during normal operation and maintenance

Note 1 to entry: Tool-based accessible compartment are submitted to special procedures.

3.108.4

non-accessible compartment

high-voltage compartment, that must not be opened

Note 1 to entry: Opening may destroy the integrity of the compartment.

3.109

connection compartment

high-voltage compartment in which electrical connections are made between the main circuit of the switchgear assembly and the external conductors (cables or bars) to the electrical network or high-voltage apparatus of the installation

Note 1 to entry: A connection compartment is not needed for a solid insulation enclosed switchgear, if the external connection can be safely touched.

3.110

partition

part of solid-insulation enclosed switchgear and controlgear separating one high-voltage compartment from other compartments and providing a specified degree of protection

Note 1 to entry: Movable shutters intended for shielding may become an integral part of the partition.

Note 2 to entry: Partitions may be fitted with parts that allow interconnection between compartments (e.g. bushings).

Note 3 to entry: In 3.111 the only partition class considered in this standard is defined. This separate clause is introduced to keep the structure similar to the corresponding clauses in IEC 62271-200.

[SOURCE: IEC 60050-441:1984, 441-13-06, modified – modification of the wording]

3.111

partition class PI

solid-insulation enclosed switchgear and controlgear having one or more non-metallic partitions or shutters between opened accessible compartments and live parts of the main circuit

3.112

shutter

part of solid-insulation enclosed switchgear and controlgear that can be moved from a position where it permits contacts of a removable part, or moving contact of a disconnecter, to engage fixed contacts, to a position where it becomes a part of the solid insulating enclosure or partition shielding the fixed contacts

[SOURCE: IEC 60050-441:1984, 441-13-07, modified – modification of the wording]

3.113

segregation (of conductors)

arrangement of conductors with earthed metal interposed between them in such a manner that disruptive discharges can only occur to earth

Note 1 to entry: A segregation may be established between the conductors as well as between the open contacts of a switching device or disconnecter.

Note 2 to entry: This definition does not specify any mechanical protection (IP and IK).

[SOURCE: IEC 60050-441:1984, 441-11-11, modified – new notes]

3.114

bushing

structure carrying one or more conductors through an enclosure or partition and insulating the conductors from the enclosure or partition, including the means of attachment

3.115

component

essential part of the main or earthing circuits of solid-insulation enclosed switchgear and controlgear which serves a specific function (for example, circuit-breaker, disconnecter, switch, fuse, instrument transformer, bushing, busbar)

3.116

solid-insulation embedded component

component, the live parts of which are integrally surrounded by solid insulating material, with the exception of the terminals, interfaces for driving mechanisms and secondary wiring

Note 1 to entry: The insulation may form part of the solid insulating enclosure.

3.117

main circuit

all the high-voltage conductive parts of solid-insulation enclosed switchgear and controlgear included in a circuit which is intended to carry the rated normal current

Note 1 to entry: Connections to voltage transformers are not considered part of the main circuit.

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – modification of the wording and new note]

3.118
earthing circuit

conductors, connections and the conducting parts of earthing devices intended to connect the high-voltage conductive parts to the earthing system of the installation

3.119
auxiliary circuit

all the conductive parts of solid-insulation enclosed switchgear and controlgear included in a circuit (other than the high-voltage parts) intended to control, measure, signal and regulate

Note 1 to entry: The auxiliary circuits of solid-insulation enclosed switchgear and controlgear include the control and auxiliary circuits of the switching devices.

[SOURCE: IEC 60050-441:1984, 441-13-03, modified – modification of the wording]

3.120
pressure-relief device

device intended to relieve over pressure from a compartment

3.121
fluid-filled compartment

high-voltage compartment of solid-insulation enclosed switchgear and controlgear filled with a fluid, either gas, other than ambient air, or liquid, for insulation purposes

3.121.1
gas-filled compartment

high-voltage compartment of solid-insulation enclosed switchgear and controlgear in which the gas pressure is maintained by one of the following systems:

- a) controlled pressure system;
- b) closed pressure system;
- c) sealed pressure system.

Note 1 to entry: Several gas-filled compartments may be permanently interconnected to form a common gas-system (gastight assembly).

Note 2 to entry: For pressure systems related to gas tightness, refer to 3.6.5 and 3.6.6 of IEC 62271-1:2007.

[SOURCE: IEC 62271-1:2007, 3.6.6.1, modified – modification of the wording]

3.121.2
liquid-filled compartment

high-voltage compartment of solid-insulation enclosed switchgear and controlgear in which the liquid is at atmospheric pressure, or under pressure that is maintained by one of the following systems:

- a) controlled pressure system;
- b) closed pressure system;
- c) sealed pressure system

Note 1 to entry: For pressure systems, refer to 3.6.5 of IEC 62271-1:2007.

3.122
relative pressure

pressure, referred to the standard atmospheric pressure of 101,3 kPa

3.123

minimum functional level (of fluid-filled compartments)

gas pressure (relative pressure) in Pa (or density) or liquid mass at and above which the rated values of the solid-insulation enclosed switchgear and controlgear are maintained

3.124

design level (of fluid-filled compartments)

gas pressure (relative pressure) in Pa (or density) or liquid mass used to determine the design of a gas-filled compartment or mass for a liquid-filled compartment

3.125

design temperature (of fluid-filled compartments)

highest temperature which can be reached by the gas or liquid under service conditions

3.126

ambient air temperature (of solid-insulation enclosed switchgear and controlgear)

temperature, determined under prescribed conditions, of the air surrounding the enclosure of solid-insulation enclosed switchgear and controlgear

3.127

removable part

part of solid-insulation enclosed switchgear and controlgear connected to the main circuit and that may be removed entirely from the solid-insulation enclosed switchgear and controlgear and replaced, even though the main circuit of the functional unit is live

[SOURCE: IEC 60050-441:1984, 441-13-08, modified – modification of the wording]

3.128

withdrawable part

removable part of solid-insulation enclosed switchgear and controlgear that can be moved to positions in which an isolating distance or segregation between open contacts is established, while the part remains mechanically attached to the enclosure

[SOURCE: IEC 60050-441:1984, 441-13-09, modified – modification of the wording]

3.129

service position

connected position

position of a removable part in which it is fully connected for its intended function

[SOURCE: IEC 60050-441:1984, 441-16-25]

3.130

earthing position (of a removable part)

position of a removable part or state of a disconnecter in which the closing of a mechanical switching device causes a main circuit to be short-circuited and earthed

[SOURCE: IEC 60050-441:1984, 441-16-26, modified – modification of the wording]

3.131

test position (of a withdrawable part)

position of a withdrawable part in which an isolating distance or segregation is established in the main circuit and in which the auxiliary circuits are connected

[SOURCE: IEC 60050-441:1984, 441-16-27]

3.132**disconnected position** (of a withdrawable part)

position of a withdrawable part in which an isolating distance or segregation is established in the circuits of the withdrawable part, that part remaining mechanically attached to the enclosure

Note 1 to entry: In high-voltage solid-insulation enclosed switchgear and controlgear, the auxiliary circuits may not be disconnected.

[SOURCE: IEC 60050-441:1984, 441-16-28, modified – modification of the wording]

3.133**removed position** (of a removable part)

position of a removable part when it is outside and mechanically and electrically separated from the enclosure

[SOURCE: IEC 60050-441:1984, 441-16-29, modified – modification of the wording]

3.134**loss of service continuity category****LSC**

category defining the possibility to keep other compartments and/or functional units energized when opening an accessible high-voltage compartment, if any, as stated in definitions 3.108.1 to 3.108.3.

Note 1 to entry: The LSC category describes the extent to which the switchgear and controlgear is intended to remain operational in case access to a main-circuit compartment is provided. The extent to which it is considered necessary to open high-voltage compartments with a live installation might be dependent on several aspects (refer to 8.103).

Note 2 to entry: The LSC category does not describe ranks of reliability of switchgear and controlgear (refer to 8.103).

Note 3 to entry: According to accessible compartments and service continuity, four categories are possible: LSC1, LSC2, LSC2A, LSC2B.

3.134.1**category LSC2 functional unit**

functional unit having at least an accessible compartment for the high-voltage connection, such that, when this compartment is open, at least one busbar can remain energized and all other functional units of the switchgear and controlgear can be operated normally

Note 1 to entry: When LSC2 functional units have accessible compartments other than the connection compartment, further subdivisions into LSC2A and LSC2B are defined.

Note 2 to entry: An accessible compartment for the high-voltage connection is called connection compartment.

3.134.1.1**category LSC2A functional unit**

functional unit of category LSC2 such that, when any accessible compartment (other than the busbar compartment of single-busbar switchgear and controlgear) is open, at least one busbar can remain energized and all other functional units of the switchgear and controlgear can be operated normally

3.134.1.2**category LSC2B functional unit**

functional unit of category LSC2A, where the high-voltage connections (e.g. cable connections) to the functional unit can remain energized when any other accessible high-voltage compartment of the corresponding functional unit is open

3.134.2**category LSC1 functional unit**

functional unit having one or more high-voltage accessible compartments, such that, when any of these accessible high-voltage compartments is open, at least one other functional unit cannot remain energised

3.135**internal arc classified switchgear and controlgear****IAC**

solid-insulation enclosed switchgear and controlgear for which prescribed criteria for protection of persons are met in the event of internal arc as demonstrated by type tests

Note 1 to entry: The internal arc classification is described by the characteristics given from 3.135.1 to 3.135.4.

3.135.1**type of accessibility**

characteristic related to the level of protection given to people accessing a defined area around the enclosure of switchgear and controlgear

3.135.2**classified sides**

characteristic related to the accessible sides having a defined level of protection of persons given by the enclosure of the switchgear and controlgear in the event of internal arc

3.135.3**arc fault current**

three-phase and – where applicable – the single phase-to-earth r.m.s. value of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

3.135.4**arc fault duration**

duration of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

3.136**degree of protection**

extent of protection provided by an enclosure, partition or shutter if applicable against access to hazardous parts, against ingress of solid foreign objects and/or ingress of water and verified by standardized test methods

[SOURCE: IEC 60529:1989, 3.3, modified – modification of the wording]

3.137**rated value**

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system

Note 1 to entry: Refer to Clause 4 for individual rated values.

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

3.138**disruptive discharge**

phenomena associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

Note 1 to entry: The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self-restoring insulation).

Note 3 to entry: The term “sparkover” is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The term “flashover” is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium. The term “puncture” is used when a disruptive discharge occurs through a solid dielectric.

3.139

electric shock

physiological effect resulting from an electric current through a human or animal body

[SOURCE: IEC 60050-195:1998, 195-01-04]

3.140

protection category against electric shock

category of protection of the accessible solid insulating surfaces against electric shock

Note 1 to entry: This protection category against electric shock is treated separately from the degree of protection, as defined in 3.136

3.140.1

protection category PA

Category of protection against electric shock in which the insulation consists of at least one layer of solid insulating material

3.140.2

protection categories PB

categories of protection against electric shock in which the insulation consists of at least one extra layer to the protection category PA layer

Note 1 to entry: Two different designs for category PB are recognized, PB1 and PB2.

Note 2 to entry: The extra layer is added as a safeguard for touching, even in case the protection category PA insulation is damaged.

3.140.2.1

protection category PB1

category of protection against electric shock in which an extra insulation layer is added to the category PA insulation

Note 1 to entry: One layer can consist of an insulating fluid.

3.140.2.2

protection category PB2

category of protection against electric shock in which an earthed conductive layer with resistance less than 100 mΩ is added to the category PA insulation

Note 1 to entry: The resistance less than 100 mΩ is defined between the accessible points of the conductive layer to the earthing point provided.

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4 Ratings

Clause 4 of IEC 62271-1:2007 is applicable, with the following addition:

The ratings of solid-insulation enclosed switchgear and controlgear are the following:

- a) rated voltage (U_r) and number of phases;
- b) rated insulation level;
- c) rated frequency (f_r);
- d) rated normal current (I_r) (for main circuits);
- e) rated short-time withstand current (I_k, I_{ke}) (for main and earthing circuits);
- f) rated peak withstand current (I_p, I_{pe}), if applicable (for main and earthing circuits);
- g) rated duration of short circuit (t_k, t_{ke}) (for main and earthing circuits);
- h) rated values of the components forming part of the solid-insulation enclosed switchgear and controlgear including their operating devices and auxiliary equipment;
- i) rated filling level (of fluid-filled compartments);
- j) ratings of the internal arc classifications (IAC), if assigned by manufacturer.

4.1 Rated voltage (U_r)

Subclause 4.1 of IEC 62271-1:2007 is applicable, except as follows.

NOTE Components forming part of solid-insulation enclosed switchgear and controlgear can have individual values of rated voltage in accordance with their relevant standards.

4.1.2 Range II for rated voltages above 245 kV

Subclause 4.1.2 of IEC 62271-1:2007 is not applicable.

4.2 Rated insulation level

Subclause 4.2 of IEC 62271-1:2007 is applicable.

4.3 Rated frequency (f_r)

Subclause 4.3 of IEC 62271-1:2007 is applicable.

4.4 Rated normal current and temperature rise

4.4.1 Rated normal current (I_r)

Subclause 4.4.1 of IEC 62271-1:2007 is applicable with the following addition:

Some main circuits of solid-insulation enclosed switchgear and controlgear (for example, busbars, feeder circuits) may have differing values of rated normal current.

4.4.2 Temperature rise

Subclause 4.4.2 of IEC 62271-1:2007 is applicable with the following addition:

The temperature rise of solid-insulation enclosed switchgear and controlgear containing components which are subject to individual specifications shall not cause these components to exceed the temperature limits permitted in the relevant standard for those components.

The maximum permissible temperatures and temperature rises to be taken into account for busbars are those specified for contacts, connections and metal parts in contact with insulation, as the case may be.

The temperature rise for accessible enclosures and covers shall not exceed 30 K for metal surfaces and 40 K for solid insulating and semi-conductive surfaces. In the case of enclosures and covers that are accessible but need not be touched during normal operation, the temperature-rise limit may be increased by 10 K.

4.5 Rated short-time withstand current (I_k)

For the rated short-time withstand currents I_k and I_{ke} , 4.5 of IEC 62271-1:2007 is applicable with the following additions:

Additional subclauses:

4.5.101 Rated short-time withstand current (I_k)

NOTE In principle, the rated short-time withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.5.102 Rated short-time phase to earth withstand current (I_{ke})

A rated short-time withstand phase to earth current shall be assigned to the earthing circuit (I_{ke}). This value may differ from that of the main circuit.

NOTE The short-circuit current ratings applicable to the earthing circuit depend upon the type of system neutral earthing for which it is intended. See 8.106.

4.6 Rated peak withstand current (I_p)

Subclause 4.6 of IEC 62271-1:2007 is applicable with the following additions:

Additional subclauses:

4.6.101 Rated peak withstand current (I_p)

NOTE In principle, the rated peak withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.6.102 Rated peak phase to earth withstand current (I_{pe})

A rated peak withstand phase to earth current shall be assigned to the earthing circuit (I_{pe}). This value may differ from that of the main circuit.

4.7 Rated duration of short circuit (t_k)

Subclause 4.7 of IEC 62271-1:2007 is applicable with the following additions:

Additional subclauses:

4.7.101 Rated duration of short circuit (t_k)

NOTE In principle, the rated duration of short circuit for a main circuit cannot exceed the corresponding rated value of the weakest of its series connected components. However, for each circuit or high-voltage compartment, advantage can be taken of apparatus limiting the duration of the short-circuit current, such as current-limiting fuses.

4.7.102 Rated duration of phase to earth short circuit (t_{ke})

A rated duration of phase to earth short circuit shall be assigned to the earthing circuit (t_{ke}). This value may differ from that of the main circuit.

4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)

Subclause 4.8 of IEC 62271-1:2007 is applicable.

4.9 Rated supply frequency of closing and opening devices and of auxiliary circuits

Subclause 4.9 of IEC 62271-1:2007 is applicable.

4.10 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 4.10 of IEC 62271-1:2007 is applicable.

4.11 Rated filling levels for insulation and/or operation

Subclause 4.11 of IEC 62271-1:2007 is applicable, except as follows.

Additional subclauses:

4.101 Ratings of the internal arc classification (IAC)

4.101.1 General

If an IAC classification is assigned by the manufacturer, several ratings shall be specified. These ratings are subdivided into type of accessibility, classified sides, arc fault currents and arc fault durations.

4.101.2 Types of accessibility

One type of accessibility to the enclosure of solid-insulation enclosed switchgear and controlgear at the site of installation is defined:

Accessibility Type A: restricted to authorized personnel only.

NOTE IAC classification as defined in this Standard does not apply to opened compartments and to arc protection between compartments. IEEE C.37.20.7 addresses these topics in Suffix B designation for opened low-voltage compartments and in Suffix C designation for arc protection between compartments; refer to [12] of Bibliography.

4.101.3 Classified sides

For accessibility type A the sides of the enclosure which meet the criteria of the internal arc test are designated as

F for front side
L for lateral side
R for rear side

The front side shall be clearly stated by the manufacturer.

4.101.4 Rated arc fault currents (I_A , I_{Ae})

The standard value of rated arc fault currents should be selected from the R 10 series specified in IEC 60059; refer to [3] of Bibliography

Two ratings of the arc fault currents are recognised:

- a) three-phase arc fault current (I_A),
- b) single phase-to earth arc fault current (I_{Ae}), when applicable.

When only a three-phase rating is specified, the single phase rating is by default 87 % of the three-phase rating, and need not be specified.

NOTE 1 The manufacturer specifies the compartments to which the single phase-to earth arc fault current rating applies. Such value is assigned to switchgear and controlgear where its construction will prevent the arc from becoming multiphase, as demonstrated during the internal arc test.

NOTE 2 Rationale for this 87 % is the arc fault test with 2-phase ignition; refer to AA.5.2

In the case where all high-voltage compartments are only designed for single phase-to-earth arc faults, I_A rating shall not be assigned (refer to AA.5.2).

NOTE 3 Information about the relationship between type of neutral earthing and the single phase-to-earth arc fault current is provided in 8.104.6.

4.101.5 Rated arc fault duration (t_A , t_{Ae})

Standard recommended values for the three-phase arc fault duration (t_A) are 0,1 s, 0,5 s and 1 s.

If applicable, the test duration (t_{Ae}) of the single phase-to-earth arc fault shall be stated by the manufacturer.

NOTE It is in general not possible to calculate the permissible arc duration for a current which differs from that used in the test.

4.102 Rated cable test voltages

4.102.1 General

If switchgear is designed to allow the dielectric testing of cables while the cables are connected to the switchgear, one or more rated cable test voltages shall be assigned by the manufacturer.

4.102.2 Rated power-frequency cable test voltage U_{ct} (a.c.)

The rated power frequency cable test voltage is the maximum a.c. test voltage that may be applied to cables when connected to the switchgear and controlgear, which may be in service.

4.102.3 Rated d.c. cable test voltage U_{ct} (d.c.)

The rated d.c. cable test voltage is the maximum d.c. test voltage that may be applied to cables when connected to the switchgear and controlgear, which may be in service.

NOTE A rated d.c. cable test voltage can be considered to also apply for very low frequency testing (e.g. 0,1 Hz). Guidance can be found in IEEE 400.2; refer to [13] of Bibliography

5 Design and construction

Clause 5 of IEC 62271-1:2007 is applicable, with the following addition:

Solid-insulation enclosed switchgear and controlgear shall be designed so that the following operations can be carried out safely:

- normal service, inspection and maintenance,
- determination of the energized or de-energized state of the main circuit, including the checking of phase sequence,
- earthing of connected cables, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of dangerous electrostatic charges.

For solid-insulation enclosed switchgear and controlgear it is necessary to take into account condensation and humidity conditions because such equipment has to be safe for persons touching it, not only in a dry state, but also with condensation on solid insulating surfaces.

All removable parts and components of the same type, rating and construction shall be mechanically and electrically interchangeable.

Removable parts and components of equal or greater current and insulation ratings may be installed in place of removable parts and components of equal or lesser current and insulation ratings where the design of these removable parts and components and compartment allows mechanical interchangeability. This does not generally apply for current-limiting devices.

NOTE Installing a removable part or component of a higher rating does not necessarily increase the capabilities of a functional unit or imply the functional unit is capable of operation at the increased ratings of the removable part or component.

The various components within the solid insulating enclosure are subject to the individual specifications applying to them.

For main circuits with current-limiting fuses, the manufacturer of the switchgear and controlgear may assign the maximum peak and Joule integral of the let-through current of the fuses to the main circuit downstream of the fuse.

5.1 Requirements for liquids in switchgear and controlgear

Subclause 5.1 of IEC 62271-1:2007 is applicable.

5.2 Requirements for gases in switchgear and controlgear

Subclause 5.2 of IEC 62271-1:2007 is applicable.

NOTE For handling of SF₆, refer to IEC/TR 62271-4. ([10] of Bibliography) .

5.3 Earthing of switchgear and controlgear

Subclause 5.3. of IEC 62271-1:2007 is applicable with the following additions:

Additional subclauses:

5.3.101 Earthing of the high-voltage conductive parts

To ensure personnel protection during maintenance work, all of the high-voltage conductive parts to which access is required or provided shall be capable of being earthed prior to becoming accessible. This does not apply to removable parts from which the high-voltage conductive parts become accessible after being separated from the switchgear and controlgear.

5.3.102 Earthing of the enclosure

If the enclosure has conductive layers intended to be earthed, there are two options:

- for category PA and PB1, the resistance to the earthing point provided is not prescribed;
- for category PB2, the resistance from any position on these conductive layers shall not exceed 100 mΩ resistance (at 30 A d.c.) to the earthing point provided.

5.3.103 Earthing of earthing devices

Where earthing connections have to carry the full three-phase short-circuit current (as in the case of the short-circuiting connections used for earthing devices), these connections shall be dimensioned accordingly.

5.3.104 Earthing of withdrawable and removable parts

The normally earthed metallic parts of a withdrawable part shall remain connected to earth in the test and disconnected positions and in any intermediate position. Connections to earth in any position shall not exceed 100 mΩ resistance (at 30 A d.c.) to the earthing point provided.

On insertion, the normally earthed metallic parts of a removable part shall be connected to earth prior to the making of the contacts of the fixed and removable parts of the main circuit.

If the withdrawable or removable part includes any earthing device, intended to earth the main circuit, then the earthing connection in the service position shall be considered as part of the earthing circuit with associated rated values (4.5, 4.6 and 4.7).

5.3.105 Earthing circuit

An earthing conductor shall be provided extending the whole length of the solid-insulation enclosed switchgear and controlgear. The earthing conductor shall be capable of carrying the rated short time and peak phase to earth withstand currents from each functional unit to the terminal which is intended for connection to the earth system of the installation. Its cross-section shall be not less than 30 mm².

NOTE 1 The current density in the earthing conductor, if of copper, does not exceed 200 A/mm² for a rated duration of short circuit of 1 s, and 125 A/mm² for a rated duration of short circuit of 3 s under the specified earth-fault conditions.

NOTE 2 A method of calculating cross-sectional areas of conductors is given in IEC 60724; refer to [6] of Bibliography.

The earthing circuit is normally designed to withstand one occurrence of a single short-circuit fault, and maintenance could be needed after such an event; refer also to 8.106.

5.4 Auxiliary and control equipment

Subclause 5.4 of IEC 62271-1:2007 is applicable.

5.5 Dependent power operation

Subclause 5.5 of IEC 62271-1:2007 is applicable.

5.6 Stored energy operation

Subclause 5.6 of IEC 62271-1:2007 is applicable.

5.7 Independent manual or power operation (independent unlatched operation)

Subclause 5.7 of IEC 62271-1:2007 is applicable.

5.8 Operation of releases

Subclause 5.8 of IEC 62271-1:2007 is applicable.

5.9 Low- and high-pressure interlocking and monitoring devices

Subclause 5.9 of IEC 62271-1:2007 is applicable.

5.10 Nameplates

Subclause 5.10 of IEC 62271-1:2007 is applicable with the following additions:

Solid-insulation enclosed switchgear and controlgear shall be provided with durable and clearly legible nameplates which shall contain the information in accordance with Table 101.

The information according to Table 101, of the complete switchgear and controlgear shall be legible during normal service. If applicable, one common nameplate for the complete switchgear and controlgear may apply with the general information, with a separate nameplate for each functional unit, containing the specific information.

Detailed information of the fixed components applied need not to be legible during normal service.

Nameplates for removable parts, need only be legible in the removed position.

Table 101 – Nameplate information

	Symbol	Unit	(**)	Condition: Marking only required if
(1)	(2)	(3)	(4)	(5)
Manufacturer			X	
Manufacturer's type designation			X	
Serial number			X	
Instruction book reference			X	
Year of manufacture			X	
Applicable standard			X	
Rated voltage	U_r	kV	X	
Rated frequency	f_r	Hz	X	
Rated lightning impulse withstand voltage	U_p	kV	X	
Rated power frequency withstand voltage	U_d	kV	X	
Rated power-frequency cable test voltage	U_{ct} (a.c.)	kV	(X)	
Rated d.c. cable test voltage	U_{ct} (d.c.)	kV	(X)	
Rated normal current	I_r	A	X	
Rated short-time withstand current	I_k	kA	X	
Rated peak withstand current	I_p	kA	Y	Different from 2,5 for 50 Hz and 2,6 for 60 Hz
Rated duration of short circuit	t_k	s	X	
Rated short-time withstand current for earthing circuits	I_{ke}	kA	Y	Different from I_k (main circuit)
Rated peak withstand current for earthing circuits	I_{pe}	kA	Y	Different from I_p (main circuit) and different from 2,5 I_{ke} for 50 Hz and 2,6 I_{ke} for 60 Hz
Rated duration of short circuit for earthing circuits	t_{ke}	s	Y	Different from t_k (main circuit)
Mass of solid insulating material		kg	X	
Rated filling level for insulation (*)	p_{re}	kPa, MPa or kg	(X)	
Alarm level for insulation (*)	p_{ae}	kPa, MPa or kg	(X)	
Minimum functional level for insulation (*)	p_{me}	kPa, MPa or kg	(X)	
Loss of Service Continuity category	LSC		X	
Insulating fluid and mass		kg	(X)	
Internal arc classification	IAC		(X)	
Type of accessibility		A	(X)	
Classified sides		F,L,R	(X)	
Arc fault current and duration	I_A, t_A	kA, s	(X)	
Single phase to earth arc fault current and duration	I_{Ae}, t_{Ae}	kA, s	Y	IAC is assigned and I_{Ae} differs from 87 % of I_A
(*) Absolute pressure (abs.) or relative pressure (rel.) to be stated (**) X = the marking of these values is mandatory; (X) = the marking of these values is as applicable; Y = conditions for the marking of these values are given in column (5).				
NOTE 1 The symbol in column (2) can be used instead of the terms in column (1).				
NOTE 2 When terms in column (1) are used, the word "rated" need not appear.				

5.11 Interlocking devices

Subclause 5.11 of IEC 62271-1:2007 is applicable with the following additions:

Interlocks between different components of the equipment are provided for reasons of protection and for convenience of operation. Interlocks shall not be damaged by attempted incorrect operations of any associated switching devices under the conditions specified in 6.102.2. The following provisions are mandatory for main circuits:

a) Solid-insulation enclosed switchgear and controlgear with removable parts:

The withdrawal or engagement of a circuit-breaker, switch or contactor shall be prevented unless it is in the open position.

The operation of a circuit-breaker, switch or contactor shall be prevented unless it is in the service, disconnected, removed, test or earthing position.

The interlock shall prevent the closing of the circuit-breaker, switch or contactor in the service position unless all auxiliary circuits associated with the automatic opening of these devices are connected. Conversely, it shall prevent the disconnection of any auxiliary circuits with the circuit-breaker closed in the service position.

b) Solid-insulation enclosed switchgear and controlgear provided with disconnectors:

Interlocks shall be provided to prevent operation of disconnectors under conditions other than those for which they are intended (refer to IEC 62271-102). The operation of a disconnector shall be prevented unless the circuit-breaker, switch or contactor is in the open position.

NOTE 1 This rule can be disregarded if it is possible to have a busbar transfer in a double busbar system without current interruption.

The operation of the circuit-breaker, switch or contactor shall be prevented unless the associated disconnector is in the closed, open or earthing position (if provided).

The provision of additional or alternative interlocks shall be subject to agreement between manufacturer and user. The manufacturer shall give all necessary information on the character and function of interlocks.

Earthing switches having a rated short-circuit making capacity less than the rated peak withstand current of the main circuit should be interlocked with the associated disconnector or main switching device in opened position.

Apparatus installed in main circuits, the incorrect operation of which can cause damage or which are used for securing isolating distances during maintenance work, shall be provided with locking facilities (for example provision for padlocks).

If earthing of a circuit is provided by the main switching device (circuit-breaker, switch or contactor) in series with an earthing switch, the earthing switch shall be interlocked with the main switching device. Provision shall be made for the main switching device to be secured against unintentional opening, for example, by disconnection of tripping circuits and blocking of the mechanical trip.

NOTE 2 Instead of an earthing switch, any other device in its earthing position is possible.

If non-mechanical interlocks are provided, the design shall be such that no improper situations can occur in case of lack of auxiliary supply. However, for emergency control, the manufacturer may provide additional means for manual operation without interlocking facilities. In such case, the manufacturer shall clearly identify this facility and define the procedures for operation.

5.12 Position indication

Subclause 5.12 of IEC 62271-1:2007 is applicable with the following addition.

In addition, for all devices involved in disconnecting and earthing functions, subclause 5.104.3 of IEC 62271-102:2001 is applicable.

5.13 Degrees of protection provided by enclosures

Subclause 5.13 of IEC 62271-1:2007 is applicable.

5.13.1 Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects (IP coding)

Subclause 5.13.1 of IEC 62271-1:2007 is applicable with the following addition:

Specific requirements are specified in 5.102 and 5.103.

5.13.2 Protection against ingress of water (IP coding)

Subclause 5.13.2 of IEC 62271-1:2007 is applicable.

5.13.3 Protection of equipment against mechanical impact under normal service conditions (IK coding)

Subclause 5.13.3 of IEC 62271-1:2007 is applicable with the following addition.

The minimum impact level is IK06 to IEC 62262 (1 J).

5.14 Creepage distances for outdoor insulators

Subclause 5.14 of IEC 62271-1:2007 is not applicable.

5.15 Gas and vacuum tightness

Subclause 5.15 of IEC 62271-1:2007 is applicable with the following addition:

Refer to 5.103.2.3.

5.16 Liquid tightness

Subclause 5.16 of IEC 62271-1:2007 is applicable with the following addition:

Refer to 5.103.2.3.

5.17 Fire hazard (flammability)

Subclause 5.17 of IEC 62271-1:2007 is applicable.

5.18 Electromagnetic compatibility (EMC)

Subclause 5.18 of IEC 62271-1:2007 is applicable.

5.19 X-ray emission

Subclause 5.19 of IEC 62271-1:2007 is applicable.

5.20 Corrosion

Subclause 5.20 of IEC 62271-1:2007 is applicable.

Additional subclauses:

5.101 Internal arc fault

Solid-insulation enclosed switchgear and controlgear that satisfy the requirements of this standard is designed and manufactured, in principle, to prevent the occurrence of internal arc faults. However, where internal arc classification is assigned, the switchgear and controlgear shall be designed to give a defined level of protection of persons in the event of an internal arc, when the switchgear and controlgear is in normal service condition.

If an internal arc classification is assigned by the manufacturer and verified by type tests according to 6.105, the classification shall be indicated by means of a designation as follows:

- Classification: IAC (InInternal Arc Classified)
- Type accessibility: A
- Classified sides of the enclosure: F, L, R
- Rated three-phase arc fault values: current [kA] and duration [s]
- Rated single-phase arc fault values (where applicable): current [kA] and duration [s]

This designation shall be included in the nameplate (refer to 5.10)

Some examples for designations of the IAC classification are given in 8.104.6.

5.102 Solid insulating enclosure

5.102.1 General

The complete solid insulating enclosure as well as the materials used in the construction shall be capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity which are likely to be encountered under the specified service conditions.

When the solid-insulation enclosed switchgear and controlgear is installed, the enclosure shall provide at least the degree of protection IP 2X, according IEC 62271-1:2007, Table 7. The specified degree of protection shall be provided by the enclosure with all the doors and covers closed as under normal service conditions, independent of how these doors and covers are held in position.

The walls of a room shall not be considered as parts of the enclosure. The floor surface below the installed switchgear and controlgear may be considered as part of the enclosure. The measures to be taken in order to obtain the degree of protection provided by floor surfaces shall be given in the installation manual.

A higher degree of protection may be specified in accordance with IEC 60529.

Parts of the enclosure bordering non-accessible compartments shall be provided with a clear indication not to be dismantled.

The horizontal surfaces of enclosures, for example, roof plates, are normally not designed to support personnel or additional equipment not supplied as part of the assembly. If the manufacturer states that it is necessary to stand or walk upon the switchgear or controlgear during operation or maintenance, the design shall be such that the relevant areas will support the weight of the operator without undue distortion and the equipment will remain suitable for its purpose. In such case, those areas on the equipment where it is not safe to stand or walk, for example, pressure relief flaps, shall be clearly identified.

5.102.2 Protection category of the solid insulating enclosure against electric shock

The solid insulating enclosure shall provide protection of persons against electric shock when touching the enclosure or operating solid-insulation enclosed switchgear and controlgear in service conditions. The following two categories of protection are distinguished:

- Protection category PA with an insulation which meets all the requirements given in the items a) to d) of 5.102.3 is generally sufficient for those parts of the enclosure which are touched by persons only accidentally or inadvertently. The insulation may be supplied with a conductive layer.

NOTE The impedance to earth of the conductive layer for category PA is not specified, as the requirement of 5.102.3 d) applies.

- Protection category PB is considered as suitable for parts of the enclosure which are liable to be touched when operating, when replacing removable parts or when carrying out other normal maintenance work. Two different designs for category PB are distinguished:
 - PB1 with an insulation which meets, in addition to those of protection category PA, the requirements given in item e) or f) of 5.102.3 as a safeguard in case the protection category PA insulation is damaged;
 - PB2 with an insulation of protection category PA, supplied with an earthed conductive layer. This earthed conductive layer shall meet the requirements given in item g) of 5.102.3.

5.102.3 Requirements for protection categories

Reference is made to the informative Annex EE for clarification.

For protection category PA, the solid insulating enclosure shall meet the following requirements:

- a) The insulation between parts of the main circuit and the accessible surface of the solid insulating enclosure of the total assembly shall be capable of withstanding the test voltages specified in 6.2.6 for dielectric tests to earth and between phases;
- b) Apart from mechanical considerations, the thickness of the insulating material of solid insulating enclosures shall be sufficient to withstand the test voltages specified in item a). The methods specified in IEC 60243-1 may be applied;
- c) The insulation between live parts of the main circuit and the inner surface of solid insulating partitions and shutters facing these shall withstand at least 150 % of U_r ;
- d) Capacitive and leakage currents shall not be greater than 0,5 mA under the specified test conditions (refer to 6.104.3). Leakage currents may reach the accessible side of the insulation by a continuous path over solid insulating surfaces or by a path broken only by small gaps of gas or liquid.

For protection category PB1, the requirements of protection category PA and one of the following additional requirements shall be met by the solid insulating enclosure.

- e) The solid insulating enclosure shall consist of at least two layers of insulating material, one of which shall comply with the requirements of item b). The other layer shall be able to withstand only a 1 min power-frequency test voltage equal to 150 % of U_r . It shall not be possible to remove the additional insulation without the aid of a tool;
- f) The solid insulating enclosure contains an insulation fluid. In these cases, it shall be ensured that the insulation of the main circuit with respect to the internal surface of the solid insulating enclosure is capable of withstanding a 1 min power-frequency test voltage equal to 150 % of U_r , even when the gaseous or liquid insulation fluid is replaced by ambient air at normal atmospheric pressure.

NOTE 1 In this case, the extra requirement for PB protection is achieved on the inside of the PA protection. Refer also to Figure EE.2b.

For protection category PB2, the requirements of protection category PA and the following additional requirement shall be met.

- g) The resistance of the earthed conductive layer shall be maximum 100 m Ω (at 30 A d.c.) to the earthing point provided.

NOTE 2 If the category PB2 is complete for the whole switchgear, IEC 62271-200 is applicable.

NOTE 3 If the resistance of the earthed conductive layer to the earthing point provided is higher than 100 mΩ (at 30 A d.c.) category PA is applicable.

5.102.4 Covers and doors

When covers and doors that are part of the enclosure are closed, they shall provide the degree of protection specified for the solid insulating enclosure.

When ventilating openings, vent outlets or inspection windows are incorporated in the cover or door, reference is made to 5.102.6 or to 5.102.7.

Covers or doors that exclusively give access to compartments which are not high-voltage compartments (e.g. low-voltage control compartment, or possible mechanism compartment), are not subject to this subclause.

Several categories of covers or doors are recognized with regard to the type of high-voltage accessible compartments they provide access to:

a) Covers or doors that give access to tool-based accessible compartments.

These covers or doors (fixed covers) need not be opened for the normal purposes of operation and/or maintenance as stated by the manufacturer. It shall not be possible for them to be opened, dismantled or removed without the use of tools;

NOTE 1 They are opened only when precautions to ensure electrical safety have been taken.

NOTE 2 Attention is paid to the requirement (if any) to carry out operation of the switching devices without voltage/current on the main circuit with doors and covers open as part of the maintenance procedures.

b) Covers or doors that give access to interlock-controlled accessible or procedure-based accessible compartments.

These covers or doors shall be provided if there is a need to access the compartment for normal operation and/or normal maintenance as stated by the manufacturer. These covers or doors shall not require tools for their opening or removal and shall have the following features.

– Interlock controlled accessible compartments:

These shall be provided with interlocking devices so that opening of the compartment shall only be possible when the part of the main circuit contained in the compartment being made accessible is dead and earthed, or in the disconnected position with corresponding shutters closed;

– Procedure-based accessible compartments:

These shall be provided with provision for locking, for example, padlocking.

NOTE 3 Suitable procedures are put in place by the user to ensure that a procedure-based accessible compartment can be opened only when the high-voltage parts contained in the compartment being made accessible is dead and earthed, or in the disconnected position with corresponding shutters closed. Procedures can be dictated by legislation of the country of installation or by user safety documentation.

NOTE 4 If interlock-controlled or procedure-based accessible compartments have other covers that can be opened by tools, proper procedures or specific warning labels can be applicable.

5.102.5 Partition or shutter being part of the enclosure

If partitions or shutters become part of the enclosure with the removable part in any of the positions defined in 3.130 to 3.133, they shall provide the degree of protection specified for the enclosure. In this case shutters also shall meet the requirements specified for protection category PB, if liable to be touched.

In this respect it may be noted:

- a partition or shutter becomes a part of the enclosure, if it is accessible in any of the positions defined in 3.130 to 3.133 and if no door is provided which can be closed in the positions defined in 3.129 to 3.133;
- if a door is provided which can be closed in the positions defined in 3.129 to 3.133 the partition or shutter behind the door is not considered to be a part of the enclosure.

5.102.6 Inspection windows

Inspection windows shall provide at least the degree of protection specified for the enclosure.

Inspection windows shall be covered by transparent sheets of mechanical strength comparable to that of the solid insulating enclosure. They shall meet at least the requirements of solid insulating enclosures specified for protection category PB.

5.102.7 Ventilating openings, vent outlets

Ventilating openings and vent outlets shall be so arranged or shielded that the same degree of protection as that specified for the solid insulating enclosure is obtained. Such openings may make use of wire mesh or the like provided that it is of suitable mechanical strength.

Ventilating openings and vent outlets shall be arranged in such a way that gas or vapour escaping under pressure does not endanger the operator.

5.103 High-voltage compartments

5.103.1 General

A high-voltage compartment shall be designated by the main component contained therein, for example, circuit-breaker compartment, busbar compartment, or by the main functionality provided, for example connection compartment, etc.

Where cable terminations are contained in a compartment with other main components (for example, circuit-breaker, busbars, etc.) then the designation shall primarily be that of the other main component.

NOTE Compartments can be further identified according to the several components enclosed, for example, connection /CT compartment, etc.

Compartments may be of various types, for example:

- air insulated;
- liquid-filled (see 5.103.2);
- gas-filled (see 5.103.2).

Openings necessary for interconnection between compartments shall be closed with bushings or other equivalent means.

Busbar compartments may extend through several functional units without the need for bushings or other equivalent means. However, in case of LSC2 equipment (see 8.103.3), separate compartments shall be provided for each set of busbars, for example, in double busbar systems and for sections of switchable or disconnectable busbars.

High-voltage parts with solid insulating material, that are intended to remain live when accessing the high-voltage compartment, shall comply with 5.102.2.

5.103.2 Fluid-filled compartments (gas or liquid)

5.103.2.1 General

Compartments shall be capable of withstanding the normal and transient pressures to which they are subjected in service.

Gas-filled compartments, when permanently pressurized in service, are subjected to particular conditions of service which distinguish them from compressed air receivers and similar storage vessels. These conditions are as follows:

- gas-filled compartments are normally filled with a non-corrosive gas, thoroughly dried, stable and inert; since measures to maintain the gas in this condition with only small fluctuations in pressure are fundamental to the operation of the switchgear and controlgear and since the compartments will not be subjected to internal corrosion, there is no need to make allowances for these factors in determining the design of the compartments;
- the design pressure is below, or equal to, 300 kPa (relative pressure).

5.103.2.2 Design

The design of a fluid-filled compartment shall be based on the nature of the fluid, the design temperature and, when applicable, on the design level as defined in this standard.

The design temperature of the fluid-filled compartment is generally the upper limit of ambient air temperature increased by the temperature rise of the fluid due to the flow of rated normal current. The design pressure of the compartment shall not be less than the upper limit of the pressure reached within the compartment at the design temperature and under the installation conditions as defined in Clause 2.

Fluid-filled compartments shall withstand:

- a) the full differential pressure possible across the compartment walls or partitions, including any evacuation process if used during filling or maintenance operations;
- b) the resulting pressure in the event of an accidental leak between the compartments in the case of adjacent compartments having different service pressures.

5.103.2.3 Tightness

The manufacturer shall state the pressure system used and the permissible leakage rate for the fluid-filled compartments (refer to 5.15 and 5.16 of IEC 62271-1:2007). This shall take into account the relative limits fixed in Table 13 of IEC 62271-1:2007 for temporarily increased leakage rates at temperatures other than 20 °C.

If requested by the user, in order to permit entry to a fluid-filled compartment of closed or controlled pressure systems, the permissible leakage across partitions should also be stated by the manufacturer.

For gas-filled compartments where the minimum functional level exceeds 100 kPa (relative pressure), an indication should be provided when the pressure at 20 °C has fallen below the minimum functional level (refer to 3.123).

A partition, separating a compartment filled with insulating gas from a neighbouring compartment filled with liquid shall not show any leakage affecting the dielectric properties of the two media.

5.103.2.4 Pressure relief of fluid-filled compartments

Where pressure-relief devices or designs are provided, they shall be arranged so as to minimize the danger to maintenance personnel and operators during the time that they are performing normal operating duties if gases or vapours are escaping under pressure. The pressure-relief devices shall not operate below 1,3 times the design pressure. The pressure-relief device may be a designed, for example, weak area of the compartment or a dedicated device, for example, a bursting disc.

5.103.3 Partitions and shutters

For the purpose of this standard, only class PI is defined for partitions and shutters between opened compartments and live parts of the main circuit, refer to 3.111.

Partitions and shutters shall provide at least the degree of protection IP2X according to IEC 62271-1:2007, Table 7.

Conductors passing through partitions shall be provided with bushings or other equivalent means to provide the required IP level.

Openings in the enclosure of solid-insulation enclosed switchgear and controlgear and in the partitions of compartments through which contacts of removable or withdrawable parts engage fixed contacts shall be provided with automatic shutters operated in normal service operations to assure the protection of persons in any of the positions defined in 3.129 to 3.133. Means shall be provided to ensure the reliable operation of the shutters, for example, by a mechanical drive, where the movement of the shutters is positively driven by the movement of the removable or withdrawable part.

The status of shutters may not in all situations be readily confirmed from an open compartment, (for example, cable compartment open but shutters mounted in breaker compartment). In such situations, verification of the shutter status may require access to the second compartment or provision of a inspection window or reliable indicating device.

If, for maintenance or test purposes, there is a requirement that one or more sets of fixed contacts shall be accessible through opened shutters, the shutters shall be provided with means of locking each set independently in the closed position. When, for maintenance or test purposes, the automatic closing of shutters is made inoperative in order to retain them in the open position, it shall not be possible to return the switching device to the service position until the automatic operation of the shutters is restored. This restoration may be achieved by the action of returning the switching device to the service position.

It may be possible to use a temporary inserted partition to prevent the live set of fixed contacts being exposed (refer to 10.4).

Partitions and shutters shall meet the following requirements:

- a) the insulation between high-voltage live parts and the accessible surface of solid insulating partitions and shutters shall withstand the test voltages specified in 4.2 of IEC 62271-1:2007 for voltage tests to earth and between poles;
- b) the solid insulating material shall withstand the power-frequency test voltage specified in item a). The appropriate test methods given in IEC 60243-1 should be applied; refer to [4] of Bibliography;
- c) the insulation between high-voltage live parts and the inner surface of solid insulating partitions and shutters facing these shall withstand at least 150 % of U_T ;
- d) if a leakage current may reach the accessible side of the solid insulating partitions and shutters by a continuous path over insulating surfaces or by a path broken only by small gaps of gas or liquid, it shall be not greater than 0,5 mA under the specified test conditions (refer to 6.104.3).

If partitions or shutters become part of the enclosure, refer to 5.102.5.

5.104 Removable parts

Removable parts for ensuring the isolating distance (in removed position) between the high-voltage conductors shall comply with IEC 62271-102, except for mechanical operation tests (refer to 6.102 and 7.102). This disconnection facility is intended for maintenance purposes only.

If removable parts are intended to be used as a disconnector or intended to be removed and replaced more often than only for maintenance purposes, then testing shall also include the mechanical operation tests according to IEC 62271-102.

The requirement that it shall be possible to know the operating position of the disconnector or earthing switch is met if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified;
- the position of the withdrawable part is indicated by a reliable indicating device.

NOTE Refer to IEC 62271-102 and also to Annex CC.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to a short circuit.

In IAC classified switchgear and controlgear, the transfer of withdrawable parts to or from the service position shall not reduce the specified level of protection in the event of an internal arc. This is achieved, for example, when the operation is only possible when doors and covers intended to ensure personnel protection are closed. Other design measures providing equivalent level of protection are acceptable.

5.105 Provisions for dielectric tests on cables

Solid-insulation enclosed switchgear and controlgear may be designed to allow the testing of cables while they are connected to the switchgear and controlgear. This may be performed either from a dedicated test connection, or from the cable terminations. The switchgear and controlgear shall then be capable of withstanding the rated cable test voltage(s) as specified in 4.102 applied to those parts which remain connected to the cable, at the same time as the rated voltage is applied to those parts of the main circuit designed to remain live during testing cables.

6 Type tests

Clause 6 of IEC 62271-1:2007 is applicable, with the following addition:

6.1 General

Subclause 6.1 of IEC 62271-1:2007 is applicable with following modifications:

Components contained in solid-insulation enclosed switchgear and controlgear which are subject to individual specifications not covered by the scope of IEC 62271-1 shall comply with, and be tested in accordance with, those specifications, taking into account the following subclauses.

The type tests shall be made on a representative functional unit. Because of the variety of types, rating and possible combinations of components, it is not practicable to make type

tests with all arrangements of the switchgear and controlgear. The performance of any particular arrangement may be substantiated by test data of comparable arrangements.

A representative functional unit may take the form of one extensible unit, However, it may be necessary to bolt two or three of such units together.

The type tests and verifications comprise:

	Subclause
Mandatory type tests:	
a) Tests to verify the insulation level of the equipment	6.2
b) Test to prove the temperature rise of any part of the equipment and measurement of the resistance of circuits	6.5 and 6.4
c) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents	6.6
d) Tests to prove the making and breaking capacity of the included switching devices	6.101
e) Tests to prove the satisfactory operation of the included switching devices and removable parts	6.102
f) Tests to verify the IP protection code	6.7.1
g) Tests to verify the protection of persons against electric shock	6.104
h) Tests to evaluate the insulation of the equipment by the measurement of partial discharges	6.2.9
i) Tests to verify auxiliary and control circuits	6.10
Mandatory type tests, where applicable:	
j) Tests to verify the protection of the equipment against mechanical impact	6.7.2
k) Tests to verify the strength of gas-filled compartments	6.103
l) Tightness tests of gas- or liquid-filled compartments	6.8
m) Tests to assess the effects of arcing due to an internal fault (for switchgear and controlgear classification IAC)	6.105
n) Electromagnetic compatibility tests (EMC)	6.9
o) X-radiation test procedures for vacuum interrupters	6.11
p) Dielectric tests on cable testing circuits	6.2.101
q) Tests to verify the thermal stability of solid insulating materials	6.106
r) Tests to assess the effects of condensation on solid insulating surfaces	6.107

Type tests may impair the suitability of the tested parts for subsequent use in service. Therefore, specimens used for type test shall not be used in service without agreement between manufacturer and user.

6.1.1 Grouping of tests

Subclause 6.1.1 of IEC 62271-1:2007 is applicable with the following modification:

The mandatory type tests (not including items m), n), o), q) and r)) shall be carried out on a maximum of four test specimens.

6.1.2 Information for identification of specimens

Subclause 6.1.2 of IEC 62271-1:2007 is applicable.

6.1.3 Information to be included in type-test reports

Subclause 6.1.3 of IEC 62271-1:2007 is applicable with the following addition:

For the report regarding internal arc tests, refer to 6.105.6.

6.2 Dielectric tests

Subclause 6.2 of IEC 62271-1:2007 is applicable, unless otherwise stated in the subclauses below.

6.2.1 Ambient air conditions during tests

Subclause 6.2.1 of IEC 62271-1:2007 is applicable.

6.2.2 Wet test procedure

Subclause 6.2.2 of IEC 62271-1:2007 is not applicable.

6.2.3 Conditions of switchgear and controlgear during dielectric tests

Subclause 6.2.3 of IEC 62271-1:2007 is applicable with the following addition:

For solid-insulation enclosed switchgear and controlgear using fluid (liquid or gas) for insulation, dielectric tests shall be performed filled with the insulating fluid specified by the manufacturer, to the minimum functional level also specified by the manufacturer.

6.2.4 Criteria to pass the test

Subclause 6.2.4 of IEC 62271-1:2007 is applicable, with the following modification:

The second paragraph of item a) that refers to wet test is not applicable.

NOTE For fluid-filled compartments tested with test bushings that are not part of the switchgear and controlgear, impulses resulting in flashover across the test bushings are not considered as part of the test series.

6.2.5 Application of the test voltage and test conditions

Subclause 6.2.5 of IEC 62271-1:2007 is applicable with the following additions.
Subclause 6.2.5.1 of IEC 62271-1:2007 is not applicable.

Because of the great variety of designs, it is not feasible to give specific indications of the tests to be performed on the main circuit, but, in principle, the power frequency – and lightning impulse voltage tests shall cover the following:

a) To earth and between phases

The test voltages specified in 6.2.6 shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit and the auxiliary circuits shall be connected to the earthing conductor and to the earth terminal of the test supply.

The dielectric tests shall be made with all switching devices closed and all removable parts in their service position. Attention shall be given to the possibility that switching devices in their open position or removable parts in the disconnected, removed, test or earthing position, may result in less favourable field conditions. Under such conditions the

tests shall be repeated. However, the removable parts shall not be subjected to these voltage tests whilst they are in the disconnected, test or removed position.

For these tests, devices such as current transformers, cable terminations, overcurrent releases/indicators shall be installed as in normal service. For impulse voltage tests, the arrangements according to 6.2.6.2 are allowed. In case of doubt about the most unfavourable arrangement, tests shall be repeated with alternative configurations.

Earthed metal plates or foils shall be placed to simulate installation conditions with lowest clearances to e.g. floor and walls, as stated by the manufacturer.

In order to check compliance with the requirement of item a) of 5.102.3, the solid insulating enclosure as well as inspection windows, partitions and shutters of solid insulating material shall be covered, on the side(s) accessible during operation or maintenance, in the most unfavourable situation for the test, with a circular or square metal foil. This foil shall have an area as large as possible, but not exceeding 100 cm², which shall be connected to earth. In case of doubt about the most unfavourable situation, the test shall be repeated in different situations. This foil shall be applied on the external surface of the enclosure without protruding into small gaps. For convenience of testing, subject to agreement between manufacturer and user, more than one metal foil may be applied simultaneously or larger parts of the enclosure may be covered.

NOTE If a subassembly is tested, it should include joints of solid insulation-embedded components if these are used.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in 6.2.6 according to the test procedures as stated in subclause 6.2.5.2 of IEC 62271-1:2007.

The isolating distance may be formed by

- a disconnector in open position;
- the distance between the two parts of the main circuit intended to be connected by a withdrawable or removable switching device.

If there is no segregation between the fixed part and the withdrawable part when an isolating distance is established, the test voltages specified for the isolating distance shall be applied in the following way: the withdrawable part shall be in whichever of the disconnected or test positions that creates the shortest distance between the fixed and movable contacts. The switching device of the withdrawable part shall be in the closed position. When it is not possible to have the switching device in the closed position (e.g. by interlocking), then two tests shall be performed as follows:

- with the withdrawable part in the position with shortest distances between the fixed and movable contacts and the switching device of the withdrawable part open;
- with the withdrawable part in the other defined position and the switching device closed.

6.2.6 Tests of switchgear and controlgear of $U_r \leq 245$ kV

Subclause 6.2.6 of IEC 62271-1:2007 is applicable with the following modifications.

The tests shall be performed with the applicable test voltages given in Table 1a or 1b of 4.2 of IEC 62271-1:2007. For test voltages to earth and between phases columns (2) and (4) shall be used. For test voltages across isolating distances columns (3) and (5) shall be used.

6.2.6.1 Power-frequency voltage tests

Subclause 6.2.6.1 of IEC 62271-1:2007 is applicable with the following provisions:

Switchgear and controlgear shall be subjected to short-duration power-frequency voltage withstand tests in accordance with IEC 60060-1. The test voltage shall be raised for each test condition to the test value and maintained for 1 min.

The tests shall be performed in dry conditions.

Instrument transformers, power transformers or fuses may be replaced by replicas reproducing the field configuration of the high-voltage connections. Overvoltage protective devices may be disconnected or removed. A transformer, a coil, or a similar device normally connected between phases shall be disconnected from the pole stressed with test voltage.

During the power-frequency voltage tests, one terminal of the test transformer shall be connected to the earthing terminal and to the metal foil or conducting cloth at the applicable points on the solid-insulation enclosed switchgear and controlgear. An exception is made for the situation where, during the tests in accordance with item b) of 6.2.5, the mid-point or another intermediate point of the voltage source should be connected to the earthing terminal in order that the voltage appearing between any of the live parts and the parts, intended to be earthed will not exceed the test voltage specified in item a) of 6.2.5.

If this is not practicable, one terminal of the test transformer may, with the agreement of the manufacturer, be connected to earth and the parts intended to be earthed of the switchgear and controlgear, shall, if necessary, be insulated from earth.

6.2.6.2 Lightning impulse voltage tests

Subclause 6.2.6.2 of IEC 62271-1:2007 is applicable with the following additions:

Instrument transformers, power transformers or fuses may be replaced by replicas reproducing the field configuration of the high-voltage connections.

Overvoltage protective devices shall be disconnected or removed. Current transformer secondary windings shall be short-circuited and earthed. Current transformers may have their primaries short-circuited too.

Procedure B of IEC 60060-1:2010 should be applied: Fifteen consecutive lightning impulses at the rated withstand voltage shall be applied for each test condition and each polarity. As an alternative, procedure C of IEC 60060-1:2010 may be applied. In this case the test consists of three consecutive impulses for each test condition and each polarity. This test procedure is referred to as the 3/9 method. The 3/9 method is accepted only when all three phases are tested.

It may be necessary for certain types of solid insulating material to eliminate residual charges before starting the tests with the opposite polarity.

During the lightning impulse voltage tests, the earthed terminal of the impulse generator shall be connected to the earthing terminal and to the metal foil or conducting cloth at the applicable points on the enclosure of the solid-insulation enclosed switchgear and controlgear, except that, during the tests in accordance with item b) of 6.2.5, the parts intended to be earthed shall, if necessary, be insulated from earth in order that the voltage appearing between any of the live parts and the parts, intended to be earthed will not exceed the test voltage specified in item a) of 6.2.5.

6.2.7 Tests of switchgear and controlgear of $U_r > 245$ kV

Subclause 6.2.7 of IEC 62271-1:2007 is not applicable.

6.2.8 Artificial pollution tests for outdoor insulators

Subclause 6.2.8 of IEC 62271-1:2007 is not applicable.

6.2.9 Partial discharge tests

Subclause 6.2.9 of IEC 62271-1:2007 is applicable with the following additions:

The tests shall be according to Annex BB.

This test shall be made after the lightning impulse and power-frequency voltage tests. Instrument transformers, power transformers or fuses may be replaced by replicas reproducing the field configuration of the high-voltage connections.

NOTE In the case of designs consisting of a combination of conventional components (for instance, instrument transformers, bushings) that can be tested separately in accordance with their relevant standards, the purpose of this partial discharge test is to check the arrangement of the components in the assembly.

This test may be carried out on assemblies or subassemblies. Care should be taken that external partial discharges do not affect the measurement.

Additional subclause:

6.2.9.101 Maximum permissible partial discharge intensity

The maximum permissible partial discharge intensity shall not exceed 20 pC for each functional unit, at $1,1 U_r$ phase-to-phase voltage, see Table BB.1.

NOTE For systems with no solidly earthed neutral, no maximum partial discharge intensity is prescribed in case of earth fault; for information only, 100 pC at $1,1 \times U_r$ phase-to-earth voltage seems to be an acceptable limit.

As a general rule, the intensity permitted for an assembly or subassembly should be the highest value permitted for its components.

6.2.10 Dielectric tests on auxiliary and control circuits

Subclause 6.2.10 of IEC 62271-1:2007 is applicable.

Current transformer secondary windings may be short-circuited and disconnected from earth. Voltage transformer secondary windings may be disconnected.

Voltage-limiting devices in the low-voltage circuit, if any, shall be disconnected.

Functions like voltage indication or detection (e.g. VPIS, VIS and VDS) which are tested according to their relevant standards are excluded.

6.2.11 Voltage test as condition check

Subclause 6.2.11 of IEC 62271-1:2007 is applicable.

Additional subclause:

6.2.101 Dielectric tests on cable testing circuits

This type test applies only to switchgear and controlgear having one or more rated cable test voltage(s).

For each rated cable test voltage value, the following test voltages shall be applied:

- a) U_r shall be applied as a single phase voltage between earth and all phase conductors on the busbar side connected together;
- b) the rated cable test voltage U_{ct} (a.c.) or U_{ct} (d.c.) shall be applied to each pole in turn of the cable test connection. The other cable test connections shall be connected to earth.

Test voltages shall be applied simultaneously.

For a.c. cable test voltages U_{ct} (a.c.) the duration of the test shall be 1 min. For d.c. cable test voltages U_{ct} (d.c.) the duration of the test shall be 15 min.

For a.c. test voltages of same frequency, the polarity of the two test voltages shall be opposite.

6.3 Radio interference voltage (r.i.v.) test

Subclause 6.3 of IEC 62271-1:2007 is not applicable.

6.4 Measurement of the resistance of circuits

6.4.1 Main circuit

Subclause 6.4.1 of IEC 62271-1:2007 is applicable with the following addition:

The measured resistance across the complete main circuit of an assembly of solid-insulation enclosed switchgear and controlgear is indicative of the proper condition of the current path. This measured resistance shall be the reference for the routine test (refer to 7.3).

6.4.2 Auxiliary circuits

Subclause 6.4.2 of IEC 62271-1:2007 is applicable.

Additional subclause:

6.4.101 Requirement for protection category PB2

If the requirement of item g) of 5.102.3 is applicable, the resistance of the earthed conductive layer shall be maximum 100 mΩ to the earthing terminal of the switchgear and controlgear. This is demonstrated by feeding at the most onerous points 30 A d.c. to the conductive layer. The corresponding voltage drop from a point on the layer nearby the point of infeed shall be a maximum of 3 V.

It might be necessary to feed the current on the conductive layer through a larger area of, for example, 1 cm², to avoid a too high density on the spot.

6.5 Temperature-rise tests

Subclause 6.5 of IEC 62271-1:2007 is applicable, with the following addition:

Where the design provides alternative components or arrangements, the test shall be performed with those components or arrangements for which the most severe conditions are obtained. The representative functional unit shall be mounted approximately as in normal service, including all normal enclosures, partitions, shutters, etc., and the covers and doors closed.

The tests shall be made normally with the rated number of phases and the rated normal current flowing from one end of the length of busbars to the terminals provided for the connection of cables.

When testing individual functional units, the neighbouring units should carry the currents which produce the power loss corresponding to the rated conditions. It is admissible to simulate equivalent conditions by means of heaters or heat insulation, if the test cannot be performed under actual conditions.

Where there are other main functional components installed within the enclosure they shall carry the currents which produce the power loss corresponding to the rated conditions. Equivalent procedures to generate the same power dissipation are acceptable.

The temperature rises of the different components shall be referred to the ambient air temperature outside the enclosure and shall not exceed the values specified for them in the relevant standards. If the ambient air temperature is not constant, the surface temperature of an identical enclosure under the same ambient conditions may be taken as reference.

6.5.1 Conditions of the switchgear and controlgear to be tested

Subclause 6.5.1 of IEC 62271-1:2007 is applicable.

6.5.2 Arrangement of the equipment

Subclause 6.5.2 of IEC 62271-1:2007 is applicable with the following change:

When the connection is realised in a compartment, the temperature of the temporary connections shall be measured at the point where they leave the enclosure and at a distance of 1 m externally. The temperature difference shall not exceed 5K.

6.5.3 Measurement of the temperature and the temperature rise

Subclause 6.5.3 of IEC 62271-1:2007 is applicable.

6.5.4 Ambient air temperature

Subclause 6.5.4 of IEC 62271-1:2007 is applicable.

6.5.5 Temperature-rise test of the auxiliary and control equipment

Subclause 6.5.5 of IEC 62271-1:2007 is applicable.

6.5.6 Interpretation of the temperature-rise tests

Subclause 6.5.6 of IEC 62271-1:2007 is applicable.

6.6 Short-time withstand current and peak withstand current tests

Subclause 6.6 of IEC 62271-1:2007 is applicable, with the following addition:

a) Test on main circuits

Main circuits of solid-insulation enclosed switchgear and controlgear shall be tested to verify their capability to withstand the rated short-time and peak withstand current under the intended conditions of installation and use, i.e. they shall be tested as installed in the solid-insulation enclosed switchgear and controlgear with all associated components influencing the performance or modifying the short-circuit current.

Connections to auxiliary devices (such as voltage transformers, auxiliary transformers, surge arresters, surge capacitors, voltage detection devices, and similar items) are not considered as parts of the main circuit.

The short-time withstand current and peak withstand current tests shall be carried out according to the rated number of phases. Current transformers and tripping devices that may be present shall be installed as in normal service, but with the release made inoperative.

Equipment which does not include any current-limiting device may be tested at any convenient voltage. Equipment which incorporates a current-limiting device shall be tested at U_r . Other test voltages can be used, if it can be demonstrated that both the applied peak current and resulting thermal effects are equal or higher than those with U_r .

For equipment including current-limiting devices the prospective current (peak, r.m.s. value and duration) shall not be less than the rated value.

Self-tripping circuit-breakers, if any, shall be set on their maximum tripping values.

Current-limiting fuses, if any, shall be provided with fuse-links having the maximum rated current specified.

After the test, no deformation or damage to components or conductors within the enclosure, which may impair good operation of the main circuits, shall have been sustained. The insulating properties of the solid insulating enclosure shall in particular be unimpaired. It may be possible to detect the presence of cracks in the insulation of solid-insulation embedded components by performing a partial discharge test (refer to 6.2.9).

b) Tests on earthing circuits

Earthing conductors, earthing connections and earthing devices of solid-insulation enclosed switchgear and controlgear shall be tested to verify their rated short-time and peak withstand currents (I_k and I_{ke} , as applicable). They shall be tested as installed in the solid-insulation enclosed switchgear and controlgear with all associated components influencing the performance or modifying the short-circuit current.

The short-time withstand current and peak withstand current tests with earthing devices shall be carried out according to the rated number of phases. Single-phase tests shall be performed on all the circuits that are intended to provide the connection between the earthing device and earthing point provided.

When there are removable earthing devices, the earthing connection between the fixed part and the removable part shall be tested under earth fault conditions. The earth fault current shall flow between the earthing conductor of the fixed part and the earthing point of the removable part. Where the earthing device in the switchgear or controlgear can be operated in alternative positions to the normal service position, for example, in double busbar switchgear and controlgear, a test shall be made in alternative positions.

After the test some deformation and degradation of the earthing conductor, earthing connections or earthing devices is permissible, but the continuity of the circuit shall be preserved.

Visual inspection should be sufficient to check that continuity of the circuit has been preserved.

In case of doubt, if certain earth connections are (still) adequate, the earthing shall be verified testing with 30 A (d.c.) to the earthing point provided. The voltage drop shall be lower than 3 V.

6.6.1 Arrangement of the switchgear and controlgear and of the test circuit

Subclause 6.6.1 of IEC 62271-1:2007 is applicable, with the following addition:

The equipment to be tested shall be arranged in such a way that the most onerous conditions are obtained concerning the maximum lengths of unsupported busbar(s), configuration of the conductors and connections within the equipment. In the case of switchgear and controlgear incorporating the same switching device in multiple high-voltage compartments, either side-by-side or in multi-tier designs, the tests shall be made with the most onerous location of the switching device.

The test connections to the terminals of the switchgear and controlgear shall be arranged in such a way as to avoid unrealistic stressing of, or support to, the terminals. The distance between the terminals and the nearest supports of the test conductors on both sides of the switchgear and controlgear shall be in accordance with the instructions of the manufacturer but taking into account the requirement above.

The switching devices shall be in the closed position and fitted with clean contacts in a new condition.

Each test shall be preceded by a no-load operation of the mechanical switching device and, with the exception of earthing switches, by measurement of the resistance of the main circuit.

The test arrangement shall be noted in the test report.

6.6.2 Test current and duration

Subclause 6.6.2 of IEC 62271-1:2007 is applicable.

6.6.3 Behaviour of switchgear and controlgear during test

Subclause 6.6.3 of IEC 62271-1:2007 is applicable.

6.6.4 Condition of switchgear and controlgear after test

Subclause 6.6.4 of IEC 62271-1:2007 is applicable.

6.7 Verification of the protection

6.7.1 Verification of the IP coding

Subclause 6.7.1 of IEC 62271-1:2007 is applicable, with the following addition:

For solid-insulation enclosed switchgear and controlgear the service conditions are with all doors and covers closed, no matter how they are expected to be locked or not.

6.7.2 Verification of the IK coding

Subclause 6.7.2 of IEC 62271-1:2007 is applicable.

6.8 Tightness tests

Subclause 6.8 of IEC 62271-1:2007 is applicable.

6.9 Electromagnetic compatibility tests (EMC)

Subclause 6.9 of IEC 62271-1:2007 is applicable.

Stationary emission tests should be performed on a typical lay out of the switchgear and controlgear, based on the standard wiring rules of the manufacturer.

6.10 Additional tests on auxiliary and control circuits

6.10.1 General

Subclause 6.10.1 of IEC 62271-1:2007 is applicable.

6.10.2 Functional tests

Subclause 6.10.2 of IEC 62271-1:2007 is not applicable:

A functional test of all low-voltage circuits shall be made to verify the proper functioning of auxiliary and control circuits in conjunction with the other parts of the switchgear and controlgear.

The tests shall be performed with the upper and lower value limits of the supply voltage defined in 4.8.

For low-voltage circuits, sub-assemblies and components, functional tests can be omitted if they have been fully performed during a test applied to similar switchgear and controlgear.

6.10.3 Electrical continuity of earthed metallic parts test

Subclause 6.10.3 of IEC 62271-1:2007 is applicable.

6.10.4 Verification of the operational characteristics of auxiliary contacts

Subclause 6.10.4 of IEC 62271-1:2007 is applicable.

6.10.5 Environmental tests

Subclause 6.10.5 of IEC 62271-1:2007 is applicable with the following limitations:

- tests do not apply for indoor switchgear and controlgear operated under normal service conditions as defined by Clause 2 of IEC 62271-1:2007;
- when the tests as stated in 6.10.5 of IEC 62271-1:2007 have been performed on the separate components of a representative auxiliary and control circuit, no further environmental tests are needed;
- when tests are performed, 6.10.5 of IEC 62271-1:2007 is applicable on a typical lay out of the auxiliary and control circuits.

6.10.6 Dielectric test

Subclause 6.10.6 of IEC 62271-1:2007 is applicable.

6.11 X-radiation test procedures for vacuum interrupters

Subclause 6.11 of IEC 62271-1:2007 is applicable.

NOTE This test is applied to the vacuum interrupter not to a functional unit.

Additional subclauses:

6.101 Verification of making and breaking capacities

6.101.1 General

Switching devices forming part of the main circuit and earthing switches of solid-insulation enclosed switchgear and controlgear shall be tested to verify their rated making and breaking capacities according to the relevant standards and under the proper conditions of installation and use. That is, they shall be tested as normally installed in the solid-insulation enclosed switchgear and controlgear with all associated components, the arrangement of which may influence the performance, such as connections, supports, provisions for venting, etc. These tests are not necessary if making and breaking tests have been performed on the switching devices installed in solid-insulation enclosed switchgear and controlgear with more onerous conditions.

In determining which associated components are likely to influence the performance, special attention should be given to mechanical forces due to the short circuit, the venting of arc products, the possibility of disruptive discharges, etc. It is recognized that, in some cases, such influences may be quite negligible.

As it is not possible to cover all possible configurations and designs of switching devices, the following procedures shall be followed:

- a) if the appropriate making and breaking current test series have been made with the switching device in a representative compartment, then the tests referred to above are also valid for compartments with similar or less onerous conditions;
- b) if type tested switching devices, tested with or without an enclosure, are used and a) is not applicable, the test duties set out in 6.101.2 and 6.101.3 below shall be repeated in each of the compartments;
- c) where compartments are designed to accept more than one particular type or design of switching device, each variant of switching device shall be fully tested in accordance with the requirements of item a) or, where appropriate item b) above.

Where multiple high-voltage compartments, either side-by-side or multi-tier designs, are not identical but are designed to accept the same switching device, the above stated tests/test-duties shall be performed in the compartment in which the most severe conditions are obtained, as appropriate to the requirements of the relevant standard.

6.101.2 Test requirements for main switching devices

The following test duties shall be performed as appropriate for the switching device.

IEC 62271-100: Test duty T100s, T100a, and critical current tests (if any) also taking into account the requirements of 6.103.4 of IEC 62271-100:2008 or the test connection arrangement, where applicable.

IEC 62271-103: Ten CO operations with rated mainly active load-breaking current (Test duty TD_{load}). Test duty TD_{ma} according to class E1, E2 or E3, as applicable, unless the switch does not have a rated short-circuit making capacity.

IEC 62271-105: Test duties TD_{Isc} and the highest value of $TD_{Itransfer}$ and TD_{Ito} .

IEC 62271-106: Verification of coordination with SCPDs to 6.106 of IEC 62271-106:2011.

6.101.3 Test requirements for earthing function

The earthing function shall be tested in accordance with the requirements of IEC 62271-102 for short-circuit making operations. The tests shall be performed in accordance with the requirements for earthing switches of class E1 or class E2, as applicable.

Where the earthing function is performed by the main switching device in combination with a class E0 earthing switch, class E1 or E2 for the earthing function may be assigned as defined in IEC 62271-102. For this arrangement the test sequence shall then be:

- for Class E1: 2C;
- for Class E2: $2C - x - 2C - y - 1C$, where x and y represent arbitrary switching or no-load operations, and 2C represents two C operations with one no-load opening operation in between, i.e. $C - O$ (no-load) – C.

The requirements of subclauses 6.101.8 and 6.101.9 of IEC 62271-102:2001, Amendment 1:2011 and Amendment 2:2013, shall apply to both the class E0 earthing switch and the main switching device.

NOTE The classification for the earthing function is not applicable when the earthing is always performed by a circuit-breaker with the protection operative until the earthed situation is attained.

6.102 Mechanical operation tests

6.102.1 Switching devices and removable parts

Switching devices shall be tested in accordance with their own product standard, unless they have already been tested. If a removable part is intended to be used as a disconnector, then the mechanical endurance shall be in accordance with IEC 62271-102.

In addition all switching devices shall be operated 50 times C-O when installed in the solid-insulation enclosed switchgear.

Removable parts shall be inserted 25 times and removed 25 times to verify satisfactory operation of the equipment. The force required to insert and remove the parts shall be less than 150 % of that required for the first operation.