

Australian Standard[®]

High-voltage switchgear and controlgear

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



This Australian Standard® was prepared by Committee EL-007, Power Switchgear. It was approved on behalf of the Council of Standards Australia on 8 November 2007. This Standard was published on 31 January 2008.

The following are represented on Committee EL-007:

- Australian British Chamber of Commerce
 - Australian Electrical and Electronic Manufacturers Association
 - Australian Railway Association
 - Energy Networks Association
 - Engineers Australia
 - Testing interests
-

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Australian Standard[®]

High-voltage switchgear and controlgear

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

Originated as AS 2264—1979.
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PREFACE

This Standard was prepared by the Standards Australia Committee EL-007, Power Switchgear to supersede AS 2264—1995, *A.C. insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 38 kV*.

The objective of this Standard is to provide requirements for alternating current insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.

This Standard is identical with, and has been reproduced from IEC 62271-201, Ed. 1.0 (2006), *High-voltage switchgear and controlgear – Part 201: AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*.

Common numbering of Standards falling under the responsibility of EL-007

In accordance with the decision taken by Committee EL-007, a common numbering system will be established in order to align the numbering of Australian Standards falling under the responsibility of EL-007 with IEC Standards. All high-voltage switchgear and controlgear Standards will, at their next revision (or as equivalent Standards become available in IEC), become parts of the AS 62271 (*High-voltage switchgear and controlgear*) series. The table below gives the relationship between future numbering and existing Standard numbers. Standards current at the time of publication of this Standard are marked with an asterisk (*).

AS 62271 Series	High-voltage switchgear and controlgear	Previous AS Number
1	Common specifications	*AS 2650
100*	High-voltage alternating-current circuit-breakers	AS 2006
102*	Alternating current disconnectors and earthing switches	AS 1306
103	Switches for rated voltages above 1 kV and less than 52 kV	*AS/NZS 60265.1
104	Switches for rated voltages of 52 kV and above	*AS 60265.2
105	Alternating current switch-fuse combinations	*AS 2024
106	Alternating current contactors and contactor-based motor-starters	*AS 60470
110*	Inductive load switching	AS 4372
200*	AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	AS 2086
201*	AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	AS 2264
202*	High-voltage/low voltage prefabricated substations	AS 61330
203*	Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	AS 2263
301*	Dimensional standardization of terminals	AS 2395
303	Use and handling of sulphur hexafluoride (SF ₆) in high-voltage switchgear and controlgear	*AS 2791
304	Additional requirements for enclosed switchgear and controlgear from 1 kV to 72.5 kV to be used in severe climatic conditions	*AS 4243
308*	Guide for asymmetrical short-circuit breaking test duty T100a	—

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

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text 'IEC 62271-201' should read 'AS 62271.201'.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

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

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NOTES

STANDARDS AUSTRALIA

Australian Standard

High-voltage switchgear and controlgear
Part 201: AC 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 factory-assembled 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.

Insulation-enclosed switchgear and controlgear complying with this standard can, in principle, be safely touched.

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 insulation-enclosed switchgear and controlgear should be 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 Switchgear and controlgear assemblies having a metal enclosure are covered by IEC 62271-200.

1.2 Normative references

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

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

~~IEC 60050-151:1978, International Electrotechnical Vocabulary (IEV)—Electrical and magnetic devices~~

AS 1852.151, *International electrotechnical vocabulary—Electric and magnetic devices* (identical to IEC 60050-151:1978)

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

AS 1852.441, *International electrotechnical vocabulary—Switchgear, controlgear and fuses* (identical to IEC 60050-441:1984)

~~IEC 60060-1:1989, High-voltage test techniques — Part 1: General definitions and test requirements~~

AS 1931.1, High-voltage test techniques, Part 1: General definitions and test requirements

IEC 60243-1:1998, Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies

~~IEC 60265-1:1998, High-voltage switches — Part 1: Switches for rated voltages above 1 kV and less than 52 kV~~

AS/NZS 60265.1, High-voltage switches—Switches for rated voltages above 1 kV and less than 52 kV

~~IEC 60270:2000, Partial discharge measurements~~

AS 60270, High-voltage test techniques—Partial discharge measurements (identical to IEC 60270:2000)

~~IEC 60470:2000, High-voltage alternating current contactors and contactor-based motor-starters~~

AS 60470, High-voltage alternating current contactors and contactor-based motor-starters (identical to IEC 60470:2000)

IEC 60480:2004, Guidelines for the checking and treatment of sulfur hexafluoride (SF₆) taken from electrical equipment and specification for its re-use

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

~~IEC 60694:1996, Common specifications for high-voltage switchgear and controlgear¹ standards~~

~~Amendment 1 (2000)~~

~~Amendment 2 (2001)~~

AS 2650, Common specifications for high-voltage switchgear and controlgear standards (IEC 60694, Ed.2.2(2002) MOD)

IEC 60909-0:2001, Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents

~~IEC 60932:1988, Additional requirements for enclosed switchgear and controlgear from 1 kV to 72.5 kV to be used in severe climatic conditions~~

AS 4243, Additional requirements for enclosed switchgear and controlgear from 1 kV to 72.5 kV to be used in severe climatic conditions (identical to IEC 60932:1988)

~~IEC 62271-100:2001, High-voltage switchgear and controlgear — Part 100: High-voltage alternating-current circuit-breakers (formerly IEC 60056)~~

AS 62271.100, High-voltage switchgear and controlgear, Part 100: High-voltage alternating-current circuit-breakers (IEC 62271-100, Ed.1.1(2003) MOD)

¹ A consolidated edition is available (2002).

~~IEC 62271-102:2002, High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches (formerly IEC 60129)~~

AS 62271.102, High-voltage switchgear and controlgear, Part 102: Alternating current disconnectors and earthing switches (IEC 62271-102, Ed.1.0(2003) MOD)

IEC 62271-105:2002, High-voltage switchgear and controlgear – Part 105: Alternating current switch-fuse combinations (formerly IEC 60420)

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

2 Normal and special service conditions

Clause 2 of IEC 60694 is applicable with the following addition:

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

NOTE If the ambient temperature exceeds the value for normal service conditions, derating may be necessary, and testing conditions may be considered.

3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as the definitions of IEC 60050(441), IEC 60050(151) and IEC 60694 apply, except where indicated. Some standard definitions are recalled here for ease of reference.

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

[IEV 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

[IEV 441-12-01]

3.103

insulation-enclosed switchgear and controlgear

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

[IEV 441-12-06, modified]

NOTE The external insulation may be supplied with a (semi-)conducting layer.

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

part of 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

[IEV 441-13-04, modified]

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

3.105**transport unit**

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

3.106**insulation enclosure**

part of 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.

The main material of the enclosure is of insulating type, and, in the case of added conductive layers, the resistance between any point of the conductive layer to the earthing point provided may be more than 100 m Ω

[IEV 441-13-01, modified]

NOTE If the resistance of the enclosure of the switchgear and controlgear to the earthing point provided is everywhere less than, or equal to, 100 m Ω , IEC 62271-200 is applicable.

3.107**compartment**

part of insulation-enclosed switchgear and controlgear enclosed except for openings necessary for interconnection, control or ventilation

[IEV 441-13-05, modified]

NOTE 1 Four types of compartments are distinguished: three that can be opened, called accessible (see 3.107.1/2/3), and one that cannot be opened, called non-accessible (see 3.107.4).

NOTE 2 Compartments are identified according to the main component(s) contained therein, refer to 5.103.1.

3.107.1**interlock-controlled accessible compartment**

compartment containing high-voltage parts, 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 Installation, extension, repairing, etc. are not considered as normal maintenance.

3.107.2**procedure-based accessible compartment**

compartment containing high-voltage parts, 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 Installation, extension, repairing, etc. are not considered as normal maintenance.

3.107.3**tool-based accessible compartment**

compartment containing high-voltage parts that may be opened, but not for normal operation and maintenance. Special procedures are required. Tools are necessary for opening

3.107.4**non-accessible compartment**

compartment containing high-voltage parts, that must not be opened. Opening may destroy the integrity of the compartment. Clear indication not to open is provided on/by the compartment

NOTE An insulation embedded component, as defined in 3.114, can generally be qualified as a 'non-accessible compartment'.

3.108**partition**

part of insulation-enclosed switchgear and controlgear separating one compartment from other compartments

[IEV 441-13-06, modified]

3.109**partition class PI**

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

3.110**shutter**

part of 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 insulation enclosure or partition shielding the fixed contacts

[IEV 441-13-07, modified]

3.111**segregation (of conductors)**

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

[IEV 441-11-11]

NOTE A segregation may be established between the conductors as well as between the open contacts of a switching device or disconnecter.

3.112**bushing**

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

3.113**component**

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

3.114**insulation-embedded component**

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

NOTE The insulation may form part of the insulation enclosure.

3.115**main circuit (of an assembly)**

all the conductive parts of insulation-enclosed switchgear and controlgear included in a circuit which is intended to transmit electrical energy

[IEV 441-13-02, modified]

NOTE Connections to voltage transformers are not considered part of the main circuit.

3.116**earthing circuit**

connection of each earthing device, or points provided for earthing purposes, to the terminal intended to be connected to the earthing system of the installation

3.117**auxiliary circuit (of an assembly)**

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

[IEV 441-13-03, modified]

NOTE The auxiliary circuits of insulation-enclosed switchgear and controlgear include the control and auxiliary circuits of the switching devices.

3.118**pressure-relief device**

device intended to limit the pressure in a fluid-filled compartment

3.119**fluid-filled compartment**

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

3.119.1**gas-filled compartment**

NOTE Refer to 3.6.5.1 of IEC 60694.

3.119.2**liquid-filled compartment**

compartment of 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 For pressure systems, refer to 3.6.4 of IEC 60694.

3.120**relative pressure**

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

3.121**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 insulation-enclosed switchgear and controlgear are maintained

3.122**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

3.123**design temperature (of fluid-filled compartments)**

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

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

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

3.125**removable part**

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

[IEV 441-13-08, modified]

3.126**withdrawable part**

removable part of 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

[IEV 441-13-09, modified]

3.127**service position (connected position) (of a removable part)**

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

[IEV 441-16-25]

3.128**earthing position (of a removable part)**

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

[IEV 441-16-26, modified]

3.129**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

[IEV 441-16-27]

3.130**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

[IEV 441-16-28, modified]

NOTE In high-voltage insulation-enclosed switchgear and controlgear, the auxiliary circuits may not be disconnected.

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

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

[IEV 441-16-29, modified]

3.132**loss of service continuity category****LSC**

category defining the possibility to keep other compartments and/or functional units energized when opening a main circuit compartment

NOTE 1 The LSC category describes the extent to which the switchgear and controlgear are intended to remain operational in case access to a main-circuit compartment is necessary. The extent to which it is considered necessary to open main-circuit compartments with a live installation might be dependent on several aspects (refer to 8.2).

NOTE 2 The LSC category does not describe ranks of reliability of switchgear and controlgear (refer to 8.2).

3.132.1**category LSC2 switchgear and controlgear**

switchgear and controlgear having accessible compartments other than the busbar compartment of a single busbar switchgear and controlgear.

For insulation-enclosed switchgear and controlgear, when any accessible compartment in a functional unit is open, all other functional units are intended to remain energized and operated normally. An exception applies in the case of the busbar compartment of single-busbar switchgear and controlgear which, when opened, prevents service continuity.

Two subdivisions are recognized:

LSC2B: switchgear and controlgear of category LSC2 where the cable compartment is also intended to remain energized when any other accessible compartment of the corresponding functional unit is open.

LSC2A: LSC2 switchgear and controlgear, other than LSC2B.

3.132.2**category LSC1 switchgear and controlgear**

insulation-enclosed switchgear and controlgear other than category LSC2

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

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

NOTE Refer to Annex A for additional information.

3.134**degree of protection**

extent of protection provided by an insulation 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.

[IEC 60529:1989, definition 3.3, modified]

3.135**rated value**

quantity value assigned, generally by a manufacturer, for a specified operating condition of a component device or equipment

[IEV 151-16-08, modified]

NOTE Refer to Clause 4 for individual rated values.

3.136**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 The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

NOTE 2 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 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.

3.137

electric shock

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

[IEV 195-01-04]

3.138

protection grade against electric shock

grade of protection of the insulation enclosure against electric shock

3.138.1

protection grade PA

for protection grade PA the insulation is generally sufficient for those parts of the enclosure which are touched by persons only accidentally or inadvertently

3.138.2

protection grade PB

protection grade PB is considered as suitable for parts which are liable to be touched. Two different designs for class PB are recognized:

- PB1 with an extra insulation in addition to the grade PA insulation, as a safeguard in case the protection grade PA insulation is damaged;
- PB2 with an earthed conductive cover/layer in addition to the grade PA insulation. The resistance between the points of this conductive layer that are liable to be touched, to the earthing point provided shall be less than 100 mΩ (refer to 3.106)

4 Ratings

The ratings of 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) (for main and earthing circuits);
- f) rated peak withstand current (I_p), if applicable (for main and earthing circuits);
- g) rated duration of short circuit (t_k) (for main and earthing circuits);
- h) rated values of the components forming part of the insulation-enclosed switchgear and controlgear including their operating devices and auxiliary equipment.
- i) rated filling level (of fluid-filled compartments).

4.1 Rated voltage (U_r)

Subclauses 4.1 and 4.1.1 of IEC 60694 are applicable.

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

4.2 Rated insulation level

Subclause 4.2 of IEC 60694 is applicable.

4.3 Rated frequency (f_r)

Subclause 4.3 of IEC 60694 is applicable.

4.4 Rated normal current and temperature rise

4.4.1 Rated normal current (I_r)

Subclause 4.4.1 of IEC 60694 is applicable with the following addition:

Some main circuits of 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 60694 is applicable with the following addition:

The temperature rise of components contained in the insulation-enclosed switchgear and controlgear which are subject to individual specifications not covered by the scope of IEC 60694 shall not exceed the temperature-rise limits permitted in the relevant standard for that component.

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 insulation 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, if not accessible to public.

4.5 Rated short-time withstand current (I_k)

Subclause 4.5 of IEC 60694 is applicable with the following addition:

A rated short-time withstand current shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

4.6 Rated peak withstand current (I_p)

Subclause 4.6 of IEC 60694 is applicable with the following addition:

A rated peak withstand current shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

NOTE In principle the rated short-time withstand current and 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 compartment, advantage may be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.7 Rated duration of short circuit (t_k)

Subclause 4.7 of IEC 60694 is applicable with the following addition:

A rated duration of short circuit shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

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

Subclause 4.8 of IEC 60694 is applicable.

4.9 Rated supply frequency of operating devices and of auxiliary and control circuits

Subclause 4.9 of IEC 60694 is applicable.

4.10 Rated pressure of compressed gas supply for insulation and/or operation

Subclause 4.10 of IEC 60694 is applicable.

4.10.1 Rated filling level (of fluid-filled compartments)

The pressure (relative pressure) in Pa (or density) or liquid mass assigned by the manufacturer referred to atmospheric air conditions of 20 °C at which the gas- or liquid-filled compartment is filled before being put into service.

5 Design and construction

Insulation-enclosed switchgear and controlgear shall be designed so that normal service, inspection and maintenance operations, determination of the energized or de-energized state of the main circuit, including the usual checking of phase sequence, earthing of connected cables, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of electrostatic charges that may result in electric shock, can be carried out safely.

For 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 insulation 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 insulation 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 fused short-circuit current.

5.1 Requirements for liquids in switchgear and controlgear

Subclause 5.1 of IEC 60694 is applicable.

5.2 Requirements for gases in switchgear and controlgear

Subclause 5.2 of IEC 60694 is applicable with the following addition:

Sulphur hexafluoride (SF₆) complying with IEC 60480 may be used.

NOTE For handling of SF₆, refer to IEC 61634.

5.3 Earthing of switchgear and controlgear

Subclause 5.3. of IEC 60694 is applicable with the following addition:

All accessible metal parts, which do not belong to a main or auxiliary circuit and which can collect electric charges that may result in electrical shock, shall be connected to the earthing terminal direct or through metallic structural parts. Thereupon, metallic frames and conductive layers shall always be connected to the earthing terminal direct or through metallic structural parts.

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

NOTE 1 For systems with solidly earthed neutral the maximum short-circuit current of the earthing circuit may reach levels up to the rated short-time withstand current of the main circuit.

NOTE 2 For systems with other than solidly earthed neutral the maximum short-time current of the earthing circuit may reach levels up to 87 % of the rated short-time withstand current of the main circuit (short circuit under conditions of double-earth fault).

The earthing circuit is normally designed for a single short-circuit withstand.

5.3.1 Earthing of the main circuit

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

5.3.2 Earthing conductor

An earthing conductor shall be provided extending the whole length of the insulation-enclosed switchgear and controlgear. The current density in the earthing conductor, if of copper, shall 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. However, its cross-section shall be not less than 30 mm². It shall be terminated by an adequate terminal intended for connection to the earth system of the installation.

If the earthing conductor is not made of copper, equivalent thermal and mechanical requirements shall be met.

NOTE As guidance, reference is made to a method of calculating cross-sectional areas of conductors given in IEC 60724, Clause 3.

5.3.3 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.

5.3.4 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.

NOTE This demand on resistance does not apply to field steering conductive layers where grade PA is applicable (refer to 3.138.1).

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.

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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)

5.4 Auxiliary and control equipment

Subclause 5.4 of IEC 60694 is applicable.

5.5 Dependent power closing

Subclause 5.5 of IEC 60694 is applicable.

5.6 Stored energy closing

Subclause 5.6 of IEC 60694 is applicable.

5.7 Independent manual operation

Subclause 5.7 of IEC 60694 is applicable.

5.8 Operation of releases

Subclause 5.8 of IEC 60694 is applicable.

5.9 Low- and high-pressure interlocking and monitoring devices

Subclause 5.9 of IEC 60694 is applicable.

5.10 Nameplates

Subclause 5.10 of IEC 60694 is applicable with the following additions:

Insulation-enclosed switchgear and controlgear shall be provided with durable and clearly legible nameplates which shall contain the information in accordance with Table 1.

Table 1 – Nameplate information

	Abbreviation	Unit	**	Condition: Marking only required if
(1)	(2)	(3)	(4)	(5)
Manufacturer			X	
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 normal current	I_r	A	X	
Rated short-time withstand current (for main and earthing circuits)	I_k	kA	X	
Rated peak withstand current (for main and earthing circuits)	I_p	kA	Y	Different from 2,5 for 50 Hz and 2,6 for 60 Hz
Rated duration of short circuit (for main and earthing circuits)	t_k	s	X	
Mass of main insulating material		kg	X	
Rated filling level for insulation	p_{re}	Pa or kg	(X)	
Alarm level for insulation	p_{ae}	Pa or kg	(X)	
Minimum functional level for insulation	p_{me}	Pa or kg	(X)	
Mass of insulating fluid		kg	(X)	
Internal arc classification	IAC		(X)	
Accessibility type (code)		A(F,L,R), B(F,L,R) or C	(X)	
Arc test current		kA	(X)	
Arc test current duration		s	(X)	
(**) 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 abbreviation in column (2) may be used instead of the terms in column (1).				
NOTE 2 When terms in column (1) are used, the word "rated" need not appear.				

The nameplates of each functional unit shall be legible during normal service. The removable parts, if any, shall have a separate nameplate with the data relating to the functional units they belong to, but this nameplate need only be legible when the removable part is in the removed position.

5.11 Interlocking devices

Subclause 5.11 of IEC 60694 is applicable with the following additions:

Interlocks between different components of the equipment are provided for reasons of protection and for convenience of operation. The following provisions are mandatory for main circuits:

a) 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 only 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 any auxiliary circuits associated with the automatic opening of these devices are connected. Conversely, it shall prevent the disconnection of the auxiliary circuits with the circuit-breaker closed in the service position.

b) 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 may 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 disconnectors.

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 the 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, also a disconnector in the 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 60694 is applicable.

5.13 Degrees of protection by enclosures

Subclause 5.13 of IEC 60694 is applicable. However for 5.13.3, the impact energy is limited to 1 J.

5.14 Creepage distances

Subclause 5.14 of IEC 60694 is applicable.

5.15 Gas and vacuum tightness

Subclause 5.15 of IEC 60694 is applicable with the following addition:

Refer to 5.103.2.3.

5.16 Liquid tightness

Subclause 5.16 of IEC 60694 is applicable with the following addition:

Refer to 5.103.2.3.

5.17 Flammability

Subclause 5.17 of IEC 60694 is applicable.

5.18 Electromagnetic compatibility (EMC)

Subclause 5.18 of IEC 60694 is applicable.

5.101 Internal fault

Insulation-enclosed switchgear and controlgear that satisfies the requirements of this standard, is designed and manufactured, in principle, to prevent the occurrence of internal faults.

The user shall make a proper selection, according to the characteristics of the network, operating procedures and service conditions, refer to 8.3.

If the switchgear and controlgear is installed, operated and maintained following the instructions of the manufacturer, there should be little probability that an internal arc occurs during its entire service life, but it cannot be completely disregarded.

Failure within the enclosure of insulation-enclosed switchgear and controlgear due either to a defect or an exceptional service condition or mal-operation may initiate an internal arc, which constitutes a hazard, if persons are present.

Experience has shown that faults are more likely to occur in some locations inside an enclosure than in others. Table 8.1 in Clause 8 gives a list of such locations, causes of failure and possible measures to decrease the probability of internal faults.

Other measures may be adopted to provide the highest possible level of protection to persons in case of an internal arc. These measures are aimed to limit the external consequences of such an event.

The following are some examples of these measures.

- Rapid fault clearance times initiated by detectors sensitive to light, pressure or heat or by a differential busbar protection.
- Application of suitable fuses in combination with switching devices to limit the let-through current and fault duration.
- Fast elimination of arc by diverting it to metallic short circuit by means of fast sensing and fast closing devices (arc eliminator).

- Remote control.
- Pressure relief device.
- Transfer of a withdrawable part to or from the service position only when the front door is closed.

The effectiveness of the design for providing the prescribed level of protection of persons in case of an internal arc, occurring entirely in air within the enclosure of the insulation-enclosed switchgear and controlgear, can be verified by testing according to Annex A. Designs which have been successfully tested qualify as IAC classified.

5.102 Insulation enclosure

5.102.1 General

The complete insulation 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 and ageing which are likely to be encountered in normal service conditions.

The main parts of the insulation enclosure may be considered as consisting of non-self-restoring insulation.

When the insulation-enclosed switchgear and controlgear is installed, the enclosure shall provide at least the degree of protection IP 2X, according to IEC 60529. The walls and the floor of a room shall not be considered as parts of the enclosure.

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

The complete insulation enclosure shall also ensure protection in accordance with the following conditions.

5.102.2 Protection grade of the insulation enclosure against electric shock

The insulation enclosure shall provide protection of persons against electric shock when touching the enclosure or operating insulation-enclosed switchgear and controlgear. The following two grades of protection are distinguished.

Protection grade 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.

Protection grade PB is considered as suitable for parts which are liable to be touched when operating, when replacing removable parts or when carrying out other normal maintenance work. Two different designs for grade PB are distinguished:

- PB1 with an insulation which meets, in addition to those of protection grade PA, the requirements given in item e) or f) of 5.102.3 as a safeguard in case the protection grade PA insulation is damaged.
- PB2 with an insulation of protection grade PA, supplied with an earthed conductive cover or layer. This earthed conductive cover or layer shall meet the requirements given in item g) of 5.102.3. as a safeguard to demonstrate that the protection grade PA insulation is sufficient.

5.102.3 Requirements for protection grades

Reference is made to the informative Annex D for clarification.

For protection grade PA, the insulation enclosure shall meet the following requirements:

- a) The insulation between parts of the main circuit and the accessible surface of the insulation 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 insulation enclosures shall be sufficient to withstand the test voltages specified in item a). The methods specified in IEC 60243 should be applied to the tests to meet the relevant requirements.
- c) The insulation between live parts of the main circuit and the inner surface of insulating partitions and shutters facing these shall withstand at least 150 % of the rated voltage of the equipment.
- d) Capacitive and leakage currents shall not be greater than 0,5 mA under the specified test conditions (refer to 6.104.2). Leakage currents may reach the accessible side of the insulation by a continuous path over insulating surfaces or by a path broken only by small gaps of gas or liquid.

For protection grade PB1, the requirements of protection grade PA and one of the following additional requirements shall be met by the insulation enclosure.

- e) The insulation 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 the rated voltage. It shall not be possible to remove the additional insulation without the aid of a tool.
- f) The insulation enclosure contains a fluid insulant or ambient air. In these cases, it shall be ensured that the insulation of the main circuit with respect to the internal surface of the insulation enclosure is capable of withstanding a 1 min power-frequency test voltage equal to 150 % of the rated voltage, even when the gaseous or liquid insulant 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 D.2b in Annex D.

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

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

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

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

5.102.4 Covers and doors

When covers and doors that are parts of the enclosure are closed, they shall provide the degree of protection specified for the insulation enclosure.

When ventilating openings, vent outlets or inspection windows are incorporated in the cover or door, reference is made to 5.102.6/7.

Several categories of covers or doors are recognized with regard to the type of accessible compartments to which they provide access.

- a) Covers or doors that give access to tool-based accessible compartments. They need not be opened for the normal purposes of operation or maintenance (fixed covers). It shall not be possible for them to be opened, dismantled or removed without the use of tools.

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

NOTE 2 Attention should be 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 should be put in place by the user to ensure that a procedure-based accessible compartment may be opened only 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. Procedures may be dictated by legislation of the country of installation or by user safety documentation.

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 3.128 to 3.131, they shall provide the degree of protection specified for the enclosure. In this case shutters also shall meet the requirements specified for protection grade PB, if liable to be touched.

NOTE 1 A partition or shutter becomes a part of the enclosure, if it is accessible in any of the positions defined in 3.128 to 3.131 and if no door is provided which can be closed in the positions defined in 3.127 to 3.131.

NOTE 2 If a door is provided which can be closed in the positions defined in 3.127 to 3.131 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 insulation enclosure. They shall meet at least the requirements of insulation enclosures specified for protection grade 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 insulation 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.