IEC 62271-200

Edition 3.1 2024-06
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

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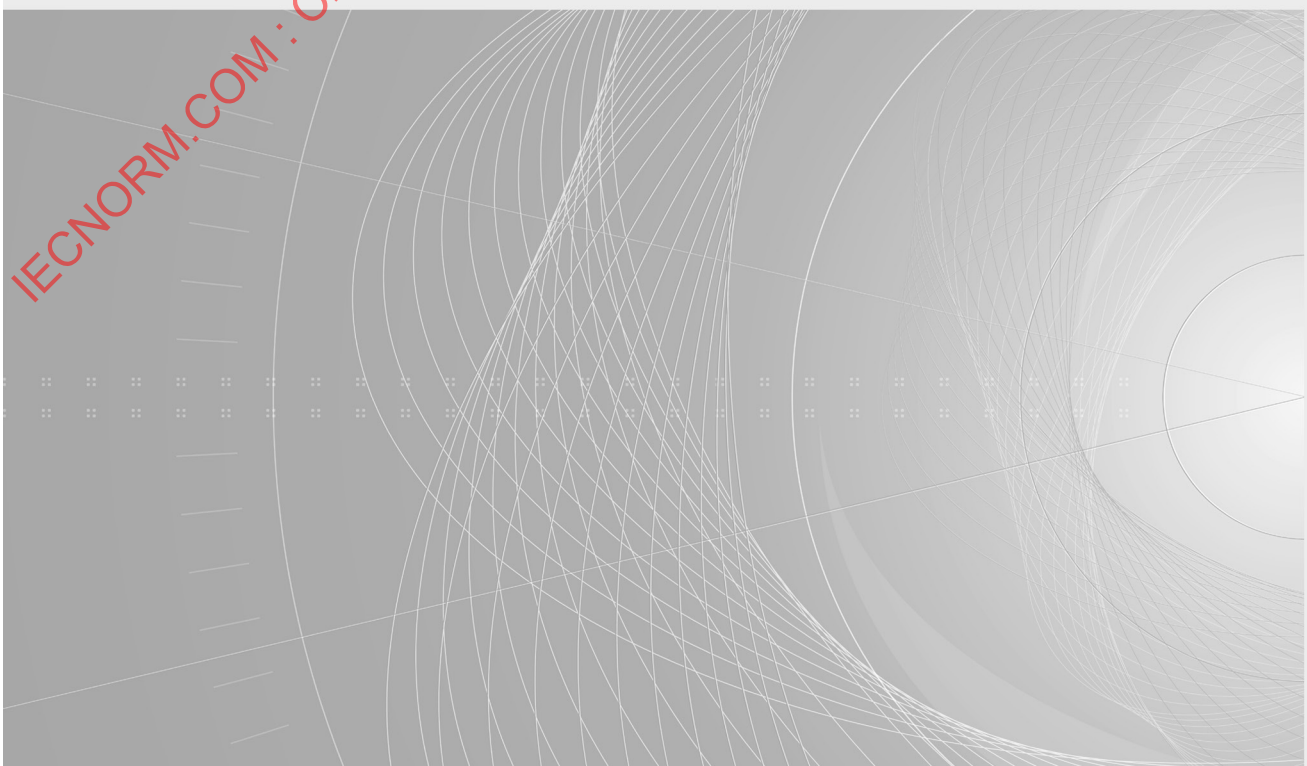
High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV



IEC 62271-200:2021-05+AMD1:2024-06 CSV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.130.10

ISBN 978-2-8322-9349-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62271-200 edition 3.1 contains the third edition (2021-05) [documents 17C/782/FDIS and 17C/792/RVD] and its amendment 1 (2024-06) [documents 17C/933/FDIS and 17C/938/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

IEC 62271-200 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

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

a) clause numbering aligned with IEC 62271-1:2017, including the adoption of the subclause names of Clause 3;
b) in Clause 3 specific definitions are added for "in service", "normal operating condition" and "normal use";
c) internal arc testing on pole-mounted switchgear is taken out of this document, as it is now covered by the specific standard IEC 62271-214:2019;
d) a more precise description of earthing circuit is given with the inclusion of ratings and test requirements;
e) number of mechanical tests on interlocks is reduced for type testing; a more precise description of forces to apply during type testing is given (refer to 7.102);
f) resistance measuring on main circuit is only needed before continuous current tests (as reference for routine tests) and no longer needed after this continuous current test. Rationale for this deletion is that this measured resistance does not mean anything; as the temperature rise test was just finished, a new temperature rise test will not give new information;
g) IEC 62271-100:2021, IEC 62271-103:2021, IEC 62271-105:2021 and IEC 62271-106:2021 are referred to in the document;
h) IEC 62271-107:2019 and IEC IEEE 62271-37-013:2015 are also considered in 7.101.2;
i) a more precise description of LSC category is given with the inclusion of an explanatory flowchart (Annex D);
j) examples not covered by the IAC test are transferred from Clause 6 to 9.103;
k) the term "assembly" is defined in Clause 3 and used as synonym for "metal-enclosed switchgear and controlgear" in this document;
l) "metallic" is replaced by "metal" where applicable;
m) 6.105 is now covered by 7.7;
n) a 1 s rule was introduced for Criterion 4 during IAC tests regarding hot gases versus glowing particles as cause of ignition;
o) a more precise description of internal arc tests for switchgear with protrusions is given in Annex A.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This document should be read in conjunction with IEC 62271-1:2017, 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 62271-1:2017. 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 C lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

A list of all parts in the IEC 62271 series, published under the general title *High-voltage switchgear and controlgear*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

High-voltage (IEC 60050-601:1985, 601-01-27) switchgear refers to rated voltages above 1 kV. However, medium-voltage is commonly used for distribution systems with rated voltages above 1 kV and generally applied up to and including 52 kV; refer to IEC 60050-601:1985, 601-01-28 [1][1].

Although primarily dedicated to three-phase systems, this document can also be applied to single-phase and two-phase systems.

Switchgear and controlgear assemblies having a solid-insulation enclosure are covered by IEC 62271-201.

Generally, gas-filled medium-voltage designs have design pressures below 500 kPa, as mentioned for example in the introduction of EN 50187.

1 Numbers in square brackets refer to the Bibliography.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

1 Scope

This part of IEC 62271 is applicable to prefabricated metal-enclosed switchgear and controlgear assemblies designed for:

– alternating current;
– rated voltages above 1 kV and up to and including 52 kV;
– service frequencies up to and including 60 Hz;
– indoor and outdoor installation.

The assembly can include air-insulated and/or fluid-filled compartments.

For components installed in a metal-enclosed switchgear and controlgear, this document supplements or even replaces in some cases, the requirements as stated by the individual product standards.

The list of components which can be inside the metal-enclosed switchgear and controlgear is not limited to the ones explicitly cited in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at http://www.electropedia.org)

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at http://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 60270:2000/AMD1:2015

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

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

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-100:2021, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

IEC 62271-102:2018, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-103:2021, *High-voltage switchgear and controlgear – Part 103: Switches for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-105:2021, *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 62271-106:2021, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

IEC 62271-107:2019, *High-voltage switchgear and controlgear – Part 107: Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-201:2014, *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*

~~IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*~~

IEC 62271-213:2021, *High-voltage switchgear and controlgear – Part 213: Voltage detecting and indicating system*

IEC 62271-215:2021, *High-voltage switchgear and controlgear – Part 215: Phase comparator used with VDIS*

IEC IEEE 62271-37-013:2015, *High-voltage switchgear and controlgear – Part 37-013: Alternating-current generator circuit-breakers*

ISO 4126-2, *Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices*

3 Terms and definitions

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

NOTE The classification system for definitions of IEC 62271-1:2017 is followed. Terms and definitions are referenced and prioritized in the following order:

– Clause 3 of this document;
– IEC 62271-1:2017;
– IEC 60050-441;
– IEC 60050-151.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General terms and definitions

The definitions in 3.1 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.1.101
ambient air temperature
<of an assembly> temperature, determined under specified conditions, of the air surrounding the enclosure of an assembly

[SOURCE: IEC 60050-441:1984, 441-11-13, modified – "prescribed" has been replaced by "specified", "complete switching device or fuse" by "enclosure of an assembly" and the note has been removed.]

3.1.102
disruptive discharge
phenomenon 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 is applicable 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 can 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 gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

3.1.103
relative pressure
pressure that refers to the local atmospheric pressure

Note 1 to entry: When defining a filling level it is in reference to the standard atmospheric pressure of 101,3 kPa, as defined in IEC 62271-1.

3.1.104
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 can be established between the conductors as well as between the open contacts of a switching device like a disconnector.

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

[SOURCE: IEC 60050-441:1984, 441-11-11, modified – Notes to entry have been added.]

3.1.105
in service
<condition of an assembly> condition where at least one high voltage part in the assembly is energized

3.1.106
normal operating condition
<of an assembly> in service condition with all doors and covers properly closed and secured

3.1.107
normal use
<of an assembly> use of the assembly as defined by the manufacturer's instructions reference, corresponding to the conditions and operations in service

Note 1 to entry: "normal use" may include maintenance activities within an accessible high-voltage compartment.

3.2 Assemblies of switchgear and controlgear

The definitions in 3.2 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.2.101
metal-enclosed switchgear and controlgear assembly
switchgear and controlgear assemblies with a metal enclosure intended to be earthed, and complete except for external connections

Note 1 to entry: This term generally is applicable to high-voltage switchgear and controlgear.

Note 2 to entry: The term "external connections" corresponds to "external conductors (cables or bars) connecting the assembly to the network or an external installation".

[SOURCE: IEC 60050-441:1984, 441-12-04, modified – The second preferred term "assembly" and Note 2 to entry have been added and in the definition "external" has been deleted.]

3.2.102
multi-tier design
design of an assembly in which the main switching devices of two or more functional units are arranged vertically (one above the other) within a common enclosure

3.3 Parts of assemblies

The definitions in 3.3 of IEC 62271-1:2017 are applicable.

3.4 Switching devices

The definitions in 3.4 of IEC 62271-1:2017 are applicable.

3.5 Parts of switchgear and controlgear

The definitions in 3.5 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.5.101
enclosure
<of an assembly> part of an assembly providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

[SOURCE: IEC 60050-441:1984, 441-13-01]

3.5.102
metal enclosure
<of an assembly> outermost enclosure made of metal, which can be composed of several elements, enclosing all high-voltage parts

3.5.103
functional unit
<of an assembly> part of an assembly comprising the main circuits, earthing circuit and auxiliary circuits that contribute to the fulfilment of a single function

Note 1 to entry: Functional units can be distinguished according to the function for which they are intended, e.g., incoming unit, through which electrical energy is normally fed into the assembly, outgoing unit, through which electrical energy is normally supplied to one or more external circuits

[SOURCE: IEC 60050-441:1984, 441-13-04, modified – "of switchgear and controlgear" and "all the components of" have been deleted; "earthing circuit" has been added.]

3.5.104
component
<of an assembly> essential part of the high-voltage or earthing circuits of an assembly which serves a specific function (e.g. circuit-breaker, disconnector, switch, fuse, earthing switch, instrument transformer, bushing, busbar)

3.5.105
main circuit
<of an assembly> all the high-voltage conductive parts of an assembly included in a circuit which is intended to carry the rated continuous current

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – "high voltage" is added and "transmit electrical energy" is replaced by "carry the rated continuous current".]

3.5.106
auxiliary circuit
<of an assembly> all the conductive parts of an assembly of 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 an assembly include the control and auxiliary circuits of the switching devices.

[SOURCE: IEC 60050-441:1984, 441-13-03, modified – "main circuit" is replaced by "high-voltage parts".]

3.5.107
earthing circuit
<of an assembly> conductors, connections, and the conducting parts of earthing devices or of the metal frame, intended to connect the high-voltage conductive parts of an assembly to the earthing point provided

Note 1 to entry: The earthing circuit can include short-circuiting circuits between poles and phase-to-earth circuits from each pole to the earthing point and/or from the short-circuiting point of phase-to-earth circuits to the earthing point provided.

3.5.108
earthing point
<of an assembly> terminal which is provided on the assembly for connection of the intended earthed parts of the assembly to the earth system of the installation

3.5.109
high-voltage compartment
<of an assembly> compartment of an assembly containing high-voltage conducting parts, enclosed except for openings necessary for interconnection, control or ventilation

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

3.5.110
interlock-controlled accessible compartment
high-voltage compartment designed to be opened for normal use, in which access is controlled by the integral design of the assembly

3.5.111
procedure-based accessible compartment
high-voltage compartment designed to be opened for normal use, in which access is controlled by a suitable procedure combined with locking

3.5.112
tool-based accessible compartment
high-voltage compartment that can be opened only through the use of tools, but not designed to be opened for normal use

3.5.113
non-accessible compartment
high-voltage compartment that is designed not to be opened by the user

Note 1 to entry: By default, every high-voltage compartment not declared accessible by the manufacturer in the manufacturer's instructions reference, is considered as a non-accessible compartment.

3.5.114
fluid-filled compartment
high-voltage compartment of an assembly, filled with a fluid, either gas, other than ambient air, or liquid, for insulation purposes

Note 1 to entry: For fluid-filled compartments with gas, the term "gas-filled compartment" is used.

Note 2 to entry: The pressure is maintained by one of the following systems:

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

Note 3 to entry: For pressure systems, refer to 3.6.6 of IEC 62271-1:2017.

3.5.115
pressure relief device
device intended to relieve overpressure from a compartment

3.5.116
partition
<of an assembly> part of an assembly separating one high-voltage compartment from other compartments and providing a specified degree of protection

Note 1 to entry: Partitions can be fitted with parts that allow interconnection between compartments (e.g. bushings).

[SOURCE: IEC 60050-441:1984, 441-13-06, modified – "high-voltage" and "and providing a specified degree of protection" have been added.]

3.5.117
bushing
insulator forming a passage for a conductor through a non-insulating partition

[SOURCE: IEC 60050-151:2001, 151-15-40]

3.5.118
shutter
<of an assembly> part of an assembly that can be moved from a position where it permits contacts of a removable part, or moving contact of a disconnector, to engage fixed contacts, to a position where it becomes a part of the enclosure or partition shielding the fixed contacts

[SOURCE: IEC 60050-441:1984, 441-13-07, modified – "moving contact of a disconnector" has been added.]

3.5.119
removable part
<of an assembly> part of an assembly that may be removed entirely from the assembly and replaced

[SOURCE: IEC 60050-441:1984, 441-13-08, modified – "even though the main circuit is alive" has been deleted.]

3.5.120
withdrawable part
<of an assembly> removable part of an assembly that can be moved to one or more positions in which an isolating distance or a segregation between open contacts is established, while the part remains mechanically attached to the assembly, even though the main circuit to which it was connected is live

[SOURCE: IEC 60050-441:1984, 441-13-09, modified – "even though the main circuit to which it was connected is live" has been added; the Note has been deleted.]

3.5.121
fuse-link
the part of a fuse (including the fuse-element(s)) intended to be replaced after the fuse has operated

Note 1 to entry: In this document the term is exclusively used in relation with high-voltage fuses.

[SOURCE: IEC 60050 441:1984, 441-18-09, modified – The Note to entry has been added.]

3.6 Operational characteristics of switchgear and controlgear

The definitions in 3.6 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.6.101
loss of service continuity category
LSC
<of a functional unit> category defining the possibility to keep other high-voltage compartments and/or functional units energized when opening ~~an accessible~~ its connection compartment or any other of its high-voltage compartment(s) accessible in normal use, as stated in definitions 3.5.110 ~~to 3.5.112~~ and 3.5.111, giving access to at least part of the high-voltage circuit contained within

Note 1 to entry: The LSC category describes the extent to which the assembly is intended to remain operational where access to a high-voltage compartment is provided. The extent to which it is considered necessary to open high-voltage compartments of an installation in service might be dependent on several aspects (refer to 9.101).

Note 2 to entry: The LSC category does not describe or relate to different levels of reliability of assemblies (refer to 9.101).

Note 3 to entry: In relation to providing access to high-voltage compartments and the associated service continuity, four categories are defined: LSC1, LSC2, LSC2A, LSC2B (refer to Annex D ~~and Figure D.1~~).

3.6.102
category LSC2
<of a functional unit> category of functional units having at least a separate accessible compartment for the high-voltage connection of that functional unit (called connection compartment), such that, when this compartment is open, at least one busbar may remain energized and all other functional units of the assembly may be operated normally

3.6.103
category LSC2A
<of a functional unit> category of functional units of category LSC2 such that, when any accessible compartment (other than its connection compartment and the busbar compartment of single-busbar assemblies) is open, at least one busbar may remain energized and all other functional units of the assembly may be operated normally

3.6.104
category LSC2B
<of a functional unit> category of functional units of category LSC2A, where the high-voltage connections (e.g. cable connections) to the functional unit may remain energized when any other accessible high-voltage compartment (other than its connection compartment and the busbar compartment of single-busbar assemblies) of the corresponding functional unit is open

3.6.105
category LSC1
<of a functional unit> category of functional units 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 shall not remain energized

3.6.106
partition class
<of an assembly> class defining whether only metal or also non-metal material is used for partitions

3.6.107
class PM
<of an assembly> partition class for an assembly providing continuous metal partitions and/or shutters (if applicable), intended to be earthed, between opened accessible compartments and high-voltage live parts

3.6.108
class PI
<of an assembly> partition class for an assembly having one or more non-metal partitions or shutters between opened accessible compartments and high-voltage live parts

3.6.109
service position
connected position
<of a removable part> position of a removable part in which it is fully connected for its intended function

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

3.6.110
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]

3.6.111
disconnected position
isolated position
<of a withdrawable part> position of a withdrawable part in which an isolating distance or segregation is established in all the circuits of the withdrawable part, that part remaining mechanically attached to the assembly

Note 1 to entry: In enclosed high-voltage switchgear and controlgear, the auxiliary circuits are generally not disconnected.

[SOURCE: IEC 60050-441:1984, 441-16-28, modified – In the Note 1 to entry, "may not be" has been replaced by "are generally not".]

3.6.112
removed position
<of a removable part> position of a removable part when it is outside and mechanically and electrically separated from the assembly

[SOURCE: IEC 60050-441:1984, 441-16-29]

3.6.113
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

Note 1 to entry: Refer to 3.3 of IEC 60529:1989.

3.6.114
minimum functional level
<of fluid-filled compartments> pressure (or density) according to definitions 3.6.5.5 and 3.6.5.6 of IEC 62271-1:2017, or liquid mass at and above which the rated values of the assembly are maintained

3.6.115
design pressure
<of fluid-filled compartments> upper limit of the relative pressure between the pressure inside a compartment at the design temperature, under defined installation conditions, and the pressure outside that compartment, that is used to determine the design of the compartment.

Note 1 to entry: The transient pressure occurring during and after a breaking operation (e.g. circuit-breaker) is not considered in the determination of the design pressure.

3.6.116
design temperature
<of fluid-filled compartments> highest average temperature over the compartment, which can be reached by the gas or liquid under service conditions

3.6.117
internal arc classification
IAC
<of an assembly> classification of an assembly for which specified criteria, for protection of persons, are met in the event of internal arc for specified installation conditions, as demonstrated by type tests

Note 1 to entry: The internal arc classification is completed with the characteristics indicated in definitions 3.6.118, 3.6.119, 3.7.101 and 3.7.102.

3.6.118
type of accessibility
<of IAC> characteristic related to the level of protection given to people accessing a defined area around the enclosure of an assembly in the event of internal arc

3.6.119
classified sides
<of IAC> accessible sides of the assembly having a defined level of protection of persons in the event of internal arc

3.7 Characteristic quantities

The definitions in 3.7 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.7.101
arc fault current
<of IAC> three-phase and, where applicable, the single-phase-to-earth RMS value of the internal arc fault current for which the assembly is designed to protect persons in the event of an internal arc

3.7.102
arc fault duration
<of IAC> duration of the internal arc fault current for which the assembly is designed to protect persons in the event of an internal arc

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4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 is applicable with the following addition:

Unless otherwise specified in this document, the assembly is designed to be used under normal service conditions.

Assemblies, under the scope of IEC TS 62271-304:2019 [2] and intended to be used in service conditions more severe with respect to condensation and pollution than the normal service conditions specified in this document, can be classified as "class 1" or "class 2" according to IEC TS 62271-304:2019 to indicate its ability to withstand such severe conditions.

NOTE IEC TS 62271-304:2019 proposes, to gain experience, further classes for service conditions with associated testing procedure in its informative Annex E.

5 Ratings

5.1 General

Subclause 5.1 of IEC 62271-1:2017 is applicable with the following additions:

k) rated short-time withstand current for earthing circuits (I_{ke});

l) rated peak withstand current for earthing circuits (I_{pe});

m) rated duration of short-circuit for earthing circuits (t_{ke});

n) ratings of the components forming part of the assembly including their operating devices and auxiliary equipment;

Optional ratings:

o) rated voltage for AC cable test voltage ($U_{ct\ (AC)}$);

p) rated voltage for DC cable test voltage ($U_{ct\ (DC)}$);

q) rated duration for DC cable test voltage ($t_{ct\ (DC)}$);

r) ratings of the internal arc classifications (IAC).

5.2 Rated voltage (U_r)

Subclauses 5.2.1 and 5.2.2 of IEC 62271-1:2017 are applicable.

NOTE Components forming part of an assembly can have individual values of rated voltage in accordance with their relevant standards.

5.3 Rated insulation level (U_d, U_p, U_s)

Subclause 5.3 of IEC 62271-1:2017 is applicable.

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2017 is applicable.

5.5 Rated continuous current (I_r)

Subclause 5.5 of IEC 62271-1:2017 is applicable with the following addition:

Some main circuits of an assembly (e.g. busbars, feeder circuits) may have different values of rated continuous current.

5.6 Rated short-time withstand currents (I_k, I_{ke})

Subclause 5.6 of IEC 62271-1:2017 is applicable with the following additions:

5.6.101 Rated short-time withstand current (I_k)

In principle, an assembly has one rated short-time withstand current value. However, there are several situations where it is permissible to assign different rated short-time withstand current values to different portions of the main circuit, including:

- circuits protected by current-limiting fuses;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated short-time withstand current values (I_k) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated short-time withstand phase-to-earth current (I_{ke}) shall be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

NOTE The short-circuit current ratings assigned to the earthing circuit define the possible earthing conditions of the system neutral of the network on which the assembly can be installed. Refer to 9.102.

5.7 Rated peak withstand currents (I_p, I_{pe})

Subclause 5.7 of IEC 62271-1:2017 is applicable with the following additions:

5.7.101 Rated peak withstand current (I_p)

In principle, an assembly has one rated peak withstand current value. However, there are several situations where it is permissible to assign different rated peak withstand current values to different portions of the main circuit, including:

- circuits protected by current-limiting fuses;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated peak withstand current values (I_p) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated peak phase-to-earth withstand current (I_{pe}) shall be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

5.8 Rated durations of short-circuit (t_k, t_{ke})

Subclause 5.8 of IEC 62271-1:2017 is applicable with the following additions:

5.8.101 Rated duration of short-circuit (t_k)

In principle, an assembly has one rated duration of short-circuit. However, there are several situations where it is permissible to assign different rated durations of short-circuit to different portions of the main circuit including:

- circuits protected by current-limiting fuses and/or circuit-breakers;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated short-time withstand current values (t_k) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated duration of phase-to-earth short-circuit (t_{ke}) shall also be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

5.9 Rated supply voltage of auxiliary and control circuits (U_a)

Subclause 5.9 of IEC 62271-1:2017 is applicable.

5.10 Rated supply frequency of auxiliary and control circuits

Subclause 5.10 of IEC 62271-1:2017 is applicable.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.11 of IEC 62271-1:2017 is applicable.

5.101 Classification of earthing function through main switching device

When the earthing function is performed by the main switching device in combination with a class E0 earthing switch, class E1 or E2, as defined in IEC 62271-102:2018, may be assigned to that earthing function.

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

5.102 Rated cable test voltages ($U_{ct\ (AC)}$, $U_{ct\ (DC)}$)

5.102.1 General

If the assembly is designed to allow for dielectric testing of connected high-voltage cables while the busbar(s) of the associated functional unit remain in service, one or more rated cable test voltages shall be assigned.

5.102.2 Rated power-frequency cable test voltage $U_{ct\ (AC)}$

The rated power-frequency cable test voltage is the maximum AC test voltage with a duration of 1 min. that may be applied to cables when connected to the assembly, which may be in service.

5.102.3 Rated DC cable test voltage $U_{ct\ (DC)}$ with rated duration $t_{ct\ (DC)}$

The rated DC cable test voltage is the maximum DC test voltage that may be applied to cables when connected to the assembly, which may be in service.

A rated DC cable test voltage is considered covering very low frequency testing (e.g. 0,1 Hz) with peak value up to the rated DC value for the same rated duration.

If no rated duration $t_{ct\ (DC)}$ is specified, then by default this duration is 15 min.

NOTE Guidance can be found in IEEE 400.2 [3].

5.103 Ratings of the internal arc classification (IAC)

5.103.1 General

If an IAC classification is assigned by the manufacturer, several ratings shall be specified. These ratings shall be indicated by means of a designation as follows:

– Classification: IAC (Internal Arc Classification);
– Type of accessibility: A, B;
– Classified sides of the enclosure: F, L, R;
– Rated three-phase arc fault values: current I_A [kA] and duration t_A [s];
– Rated single-phase arc fault values (where applicable): current I_{Ae} [kA] and duration t_{Ae} [s].

5.103.2 Types of accessibility

Two types of accessibility to the enclosure of an assembly at the site of installation are defined:

– Accessibility Type A: restricted to authorized personnel only;
– Accessibility Type B: unrestricted accessibility, including that of the general public.

NOTE 1 For pole-mounted switchgear and controlgear, refer to IEC 62271-214 [4].

NOTE 2 IAC classification as defined in this document does not apply to opened compartments and to arc protection between compartments, except if opening is necessary to perform switching operations. IEEE C37.20.7 defines Suffix B designation for opened low-voltage compartments and Suffix C designation for arc protection between compartments [5].

5.103.3 Classified sides

In case of IAC, at least the front side of the assembly shall be classified for at least accessibility type A, by the manufacturer. The sides of the assembly 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.

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

The value of rated arc fault currents should be selected from the R10 series specified in IEC 60059 [6].

Two ratings of the arc fault currents are recognized:

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

The manufacturer shall specify the compartments to which the single-phase-to-earth arc fault current rating is applicable. Such value may be assigned to an assembly where its construction will prevent the arc from becoming multiphase, as demonstrated during the internal arc test.

In the case where all high-voltage compartments are only designed for single-phase-to-earth arc faults, instead of I_A, the I_{Ae} rating shall be assigned.

NOTE Information about the relationship between the type of network neutral earthing and the single-phase-to-earth arc fault current is provided in 9.103.6.

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

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

If applicable, the rated duration (t_{Ae}) of the single-phase-to-earth arc fault shall be assigned 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.

6 Design and construction

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC 62271-1:2017 is applicable.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC 62271-1:2017 is applicable

NOTE For the handling of SF_6 and its mixtures refer to IEC 62271-4 [7].

6.3 Earthing of switchgear and controlgear

Subclause 6.3 of IEC 62271-1:2017 is applicable with the following additions:

6.3.101 Earthing of the high-voltage conductive parts

All high-voltage conductive parts to which access is provided with the assembly in service, shall have the possibility of being earthed prior to becoming accessible. This is not applicable to removable parts which become accessible after being separated from the assembly and to withdrawable parts in test position or in disconnected position (refer to 6.101).

Where earthing connections shall be able 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.

The connection from the short-circuiting point between phases to the earthing circuit may be dimensioned to the specifications of the earthing circuit.

6.3.102 Earthing of enclosure(s)

Metal enclosure(s) shall be electrically connected (directly or indirectly) to the earthing point provided. Small parts fixed to metal enclosure(s), up to a maximum of 12,5 mm in diameter, for example screw heads, need not be electrically connected to the earthing point provided. All the metallic parts intended to be earthed and not belonging to a high-voltage or auxiliary circuit shall also be electrically connected to the earthing point provided.

The interconnections within each functional unit shall be made by adequate means (e.g. fastening by bolting or welding), providing electrical continuity between the frame, covers, doors, metal partitions or other structural parts to the earthing point. Doors of the high-voltage compartments shall be electrically connected to the frame by adequate means.

NOTE 1 Enclosure and doors are considered in 6.102.

NOTE 2 EMC demands for the complete installation can require a special approach of the earthing circuit of the assembly.

6.3.103 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 provide a current-carrying capability not less than that required for enclosures (refer to 6.102.1).

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.

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 (refer to 5.6, 5.7 and 5.8).

6.3.104 Earthing circuit

The parts of the earthing circuit of the assembly connecting each functional unit to the earthing point shall be capable of carrying the rated short-time and peak phase-to-earth withstand current (I_{ke}, I_{pe}) and duration (t_{ke}).

NOTE 1 It is assumed that the short-circuiting point between phases of the earthing circuit is within each functional unit.

For transport units to be assembled during final installation, the resulting earthing circuit shall be capable of carrying its rated short-time and peak withstand currents and duration.

Parts of metal enclosures may form part of the earthing circuit.

If a dedicated earthing conductor is applied as earthing circuit of the assembly, its cross-section shall be not less than 50 mm^2.

NOTE 2 If the earthing circuit consists of an earthing copper conductor extending the whole length of the assembly, for the rated short-time withstand current, a current density in the earthing conductor, not exceeding 200 A/mm^2 for a rated duration of 1 s or 125 A/mm^2 for a rated duration of 3 s is generally sufficient.

NOTE 3 A method of calculating cross-sectional areas of conductors is given in IEC 60724 [8].

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 9.102.

6.4 Auxiliary and control equipment and circuits

Subclause 6.4 of IEC 62271-1:2017 is applicable.

6.5 Dependent power operation

Subclause 6.5 of IEC 62271-1:2017 is applicable.

6.6 Stored energy operation

Subclause 6.6 of IEC 62271-1:2017 is applicable.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC 62271-1:2017 is applicable.

6.8 Manually operated actuators

Subclause 6.8 of IEC 62271-1:2017 is applicable.

6.9 Operation of releases

Subclause 6.9 of IEC 62271-1:2017 is applicable.

6.10 Pressure/level indication

Subclause 6.10 of IEC 62271-1:2017 is applicable with the following addition to 6.10.1 of IEC 62271-1:2017.

For gas-filled compartments where the minimum functional pressure exceeds 200 kPa (absolute pressure at 20 °C) an indication shall be provided when the absolute pressure at 20 °C has fallen below the minimum functional level (refer to 3.6.114).

NOTE 1 The indication might include monitoring of pressure (density).

Closed pressure systems with minimum functional pressure above 200 kPa (absolute pressure) shall have a defined alarm pressure (density) level.

NOTE 2 Alarm pressure (density) is defined in IEC 62271-1:2017, 3.6.5.3 and 3.6.5.4.

An example of pressure coordination chart is shown in Figure E.1.

6.11 Nameplates

Subclause 6.11 of IEC 62271-1:2017 is applicable, except for Table 9, with the following additions:

Assemblies 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	Marking (**)	Condition: Marking only required if
(1)[a,b]	(2)[a]	(3)	(4)	(5)
Name of manufacturer			X	
Manufacturer's type designation			X	
Serial number			X	
Manufacturer's instructions 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	$U_{ct\ (AC)}$	kV	(X)	

	Abbreviation	Unit	Marking (**)	Condition: Marking only required if
(1)[a,b]	(2)[a]	(3)	(4)	(5)
Rated DC cable test voltage	$U_{ct\ (DC)}$	kV	(X)	
Rated duration for DC cable test	$t_{ct\ (DC)}$	min	(X)	
Rated continuous current	I_r	A	X	
Rated short-time withstand current	I_k	kA	X	
Rated peak withstand current	I_p	kA	X	
Rated duration of short-circuit	t_k	s	X	
Rated short-time phase-to-earth withstand current	I_{ke}	kA	Y	different from I_k (main circuit)
Rated peak phase-to-earth withstand current	I_{pe}	kA	Y	different from I_p
Rated duration of phase-to-earth short-circuit	t_{ke}	s	Y	different from t_k (main circuit)
Filling level for insulation and/or switching (*)	p_{re}, ρ_{re}, m_{re}	kPa, kg/m^3 or kg	(X)	
Alarm level for insulation and/or switching (*)	p_{ae}, ρ_{ae}, m_{ae}	kPa, kg/m^3 or kg	Y	closed pressure system with minimum functional pressure above 200 kPa (abs.)
Minimum functional level for insulation and/or switching (*)	p_{me}, ρ_{me}, m_{me}	kPa, kg/m^3 or kg	(X)	
Filling level for operation (*)	p_{rm}, ρ_{rm}, m_{rm}	kPa, kg/m^3 or kg	(X)	
Alarm level for operation (*)	p_{am}, ρ_{am}, m_{am}	kPa, kg/m^3 or kg	Y	closed pressure system with minimum functional pressure above 200 kPa (abs.)
Minimum functional level for operation (*)	p_{mm}, ρ_{mm}, m_{mm}	kPa, kg/m^3 or kg	(X)	
Loss of service continuity category	LSC		(X)	
Internal arc classification	IAC		(X)	
Type of accessibility	A or B		(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	(X)	
Rated supply voltage(s) of auxiliary and control circuits. Specify DC/AC (with rated frequency)	U_a	V	(X)	
Type and mass of fluid (liquid or gas) for insulation	M_f	kg	(X)	
Mass of the assembly (including any fluid)	M	kg	Y	more than 300 kg
Minimum and maximum ambient air temperature		°C	Y	different from – 5 °C and/or 40 °C

(*) Density or absolute pressure (abs.) or relative pressure (rel.) to be stated at 20°C for gases, and mass for liquids

(**) X = the marking of these values is mandatory;

(X) = the marking of these values is where applicable;

Y = conditions for marking of these values are given in column (5).

	Abbreviation	Unit	Marking (**)	Condition: Marking only required if
(1)[a,b]	(2)[a]	(3)	(4)	(5)
[a] The abbreviation in column (2) can be used instead of the terms in column (1).				
[b] When terms in column (1) are used, the word "rated" need not appear.				

The information according to Table 1, of the complete assembly, shall be legible during normal service. If applicable, one common nameplate for the complete assembly 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 be legible during normal service.

The removable parts, if any, shall have a separate nameplate which, if applicable, may contain data relating to the functional unit(s) they are designed for. These nameplates need only be legible when the removable part is in the removed position.

NOTE Fuses are removable devices that do not require such specific information because they respond to standardized dimensions.

6.12 Locking devices

Subclause 6.12 of IEC 62271-1:2017 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 7.102.2. The following provisions are defined for switching devices of main and earthing circuits.

a) For removable parts of assemblies
   - the withdrawal or engagement of any switching device shall be prevented unless it is in the open position;
   - the operation of any switching device shall be prevented unless it is only in the service, disconnected, removed or test position;
   - the interlock shall prevent the closing of any switching device 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) For other parts of assemblies
   - interlocks shall be provided to prevent operation of disconnectors under conditions other than those for which they are intended (refer to IEC 62271-102:2018). The operation of a disconnector shall be prevented unless the circuit is open. The following are exempt:
     - switch-disconnector;
     - double busbar system designed to have a busbar transfer without current interruption.
   - the operation of the circuit-breaker, switch or contactor shall be prevented by interlocks as long as the associated switching devices, i.e. disconnector and/or earthing switch, have not reached their dedicated closed or open position;
   - if earthing of a circuit is provided by the main switching device (circuit-breaker, switch or contactor) in series with an earthing switch (or any earthing device), 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/or blocking of the mechanical trip;

– 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 switching devices.

Regarding removable fuse-links, their withdrawal or engagement shall be prevented unless the fuse-base contacts are earthed or isolated from all sources of supply; see also 6.101.

The manufacturer shall give all necessary information on the character and function of interlocks.

NOTE For interlocks with covers and doors, refer to 6.102.2.

If electrical 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 a case, the manufacturer shall clearly identify this facility and define the procedures for operation.

6.13 Position indication

Subclause 6.13 of IEC 62271-1:2017 is applicable. In addition, for all devices involved in disconnecting and earthing functions, 6.104.3 of IEC 62271-102:2018 is applicable.

6.14 Degrees of protection provided by enclosures

6.14.1 General

Subclauses 6.14.1, of IEC 62271-1:2017 is applicable.

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

Subclause 6.14.2 of IEC 62271-1:2017 is not applicable. The minimum degree of protection shall be IP2X, according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

Additional requirements are specified in 6.102 and 6.103.

6.14.3 Protection against ingress of water (IP coding)

Subclause 6.14.3 of IEC 62271-1:2017 is applicable.

6.14.4 Protection of equipment against mechanical impact under normal operating conditions (IK coding)

Subclause 6.14.4 of IEC 62271-1:2017 is applicable with the following addition:

For indoor installation, the minimum impact level shall be IK07 according to IEC 62262 (2 J).

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC 62271-1:2017 is not applicable.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is applicable with the following addition:

Additional requirements are specified in 6.103.2.3.

6.17 Tightness for liquid systems

Subclause 6.17 of IEC 62271-1:2017 is applicable with the following addition:

Additional requirements are specified in 6.103.2.3.

6.18 Fire hazard (flammability)

Subclause 6.18 of IEC 62271-1:2017 is applicable.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC 62271-1:2017 is applicable.

6.20 X-ray emission

Subclause 6.20 of IEC 62271-1:2017 is applicable.

6.21 Corrosion

Subclause 6.21 of IEC 62271-1:2017 is applicable.

6.22 Filling levels for insulation, switching and/or operation

Subclause 6.22 of IEC 62271-1:2017 is applicable.

6.101 General requirements for assemblies

Assemblies shall be designed so that the operations in normal use can be carried out safely. Examples of operations a manufacturer can define as normal use are:

– determination of the presence or absence of voltage related to "in service conditions" on the main circuit including the checking of phase sequence, refer to IEC 62271-213:2021 and IEC 62271-215:2021;
– earthing of connected cables, locating of cable faults, voltage tests on connected cables;
– the elimination of dangerous trapped electrostatic charges.

In the case where a high-voltage compartment may be opened, i.e. accessible compartment, safe operation of the assembly requires (irrespective of whether of fixed or withdrawable pattern) that the high-voltage parts are isolated from all sources of supply and earthed. Exempted from this requirement are:

– high-voltage parts that are moved to the disconnected position with corresponding shutters closed;
– high-voltage parts, if embedded by solid-insulation material and complying with at least protection category PA of IEC 62271-201:2014.

Disconnecting devices used for isolation shall be secured against re-connection.

If a withdrawable or removable part does not include an earthing device that is intended to earth the main circuit of that removable part before becoming accessible, it shall be possible, by manual earthing means, to safely discharge trapped charges from that removable part. The manufacturer shall define the recommended procedure in the manufacturer's instructions reference.

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 interchange ability. 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 that the functional unit is capable of operation at the increased ratings of the removable part or component.

Components contained in an assembly shall be in accordance with their various relevant standards. This document supplements or even replaces the standards for the individual components regarding their installation in assemblies.

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

6.102 Metal enclosure

6.102.1 General

The walls of a room shall not be considered as parts of the enclosure. The floor surface below the installed assembly 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.

The enclosure shall be metal. The following exceptions apply:

– parts of the enclosure may be of non-metal material, provided that all high-voltage parts are completely enclosed by metal partitions or shutters that are connected to the earthing circuit;
– inspection windows complying with 6.102.4;
– the floor surface below the installed assembly provided that it is solid and does not allow access underneath the assembly.

When the assembly is installed, the enclosure shall provide at least the degree of protection IP2X, according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013. The specified degree of protection shall be provided by the enclosure with all the doors and covers closed as under normal operating conditions, irrespective of how these doors and covers are held in position.

Enclosures shall also ensure protection in accordance with the following conditions:

– Metal parts of the enclosures shall be designed to carry 30 A (DC) with a voltage drop of maximum 3 V to the earthing point provided.
– Parts of the enclosure enclosing tool-based-accessible high-voltage compartments shall be provided with a clear labelling of the electrical risk if removed or opened.
– 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 assembly during operation or maintenance, the design shall be such that the relevant areas will support the weight of the operator. In such a case, the IP degree shall not be affected as well as no permanent deformation is allowed and the areas on the equipment where it is not safe to stand or walk, for example pressure relief flaps, shall be clearly identified.

6.102.2 Covers and doors

Covers and doors that are part of the enclosure shall be made of metal. However, covers and doors may be made of insulating material, provided that high-voltage parts are enclosed by metal partitions or shutters connected to the earthing point provided.

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

Covers and doors shall not be made of woven wire mesh, expanded metal or similar. When ventilating openings, vent outlets or inspection windows are incorporated in the cover or door, reference is made to 6.102.4 or to 6.102.5.

Covers and 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 and doors are recognized with regard to the type of high-voltage accessible compartments they provide access to:

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

These covers and doors (fixed covers) need not be opened for normal use as stated by the manufacturer. It shall not be possible for them to be opened, dismantled or removed without the use of tools. Special procedures are required to safeguard that opening can only be realized if precautions to ensure electrical safety have been taken.

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

These covers and doors shall be provided if there is a need to access the compartment for normal use as stated by the manufacturer. These covers and doors shall not require tools for their opening or removal. It is permissible that the manipulation of some fixing elements for their opening or removal is required, and they shall have the following features:

– interlock controlled accessible compartments shall be provided with interlocking devices so that opening of the compartment shall only be possible when the high-voltage parts contained in the compartment being made accessible are isolated and earthed, or are in the disconnected position with corresponding shutters closed;

– procedure-based accessible compartments shall be provided with provision for locking, e.g. padlocking. Suitable procedures should be put in place by the user to ensure that a procedure-based accessible compartment is opened only when the high-voltage parts contained in the compartment being made accessible are isolated and earthed, or in the disconnected position with corresponding shutters closed. Procedures ~~may~~ can be dictated by the legislation of the country of installation or by the user safety documentation.

NOTE Examples of fixing elements are screws, bolts, nuts, turning fasteners and sliding fasteners.

If interlock-controlled or procedure-based accessible compartments have ~~other~~ covers that can be opened by tools, other than those that are interlocked or locked, proper procedures or specific warning labels should be applied.

Access to a closed interlock-controlled or procedure-based compartment through covers needing only the use of tools to be opened or removed is not intended for normal use. Once an interlocked or locked door or cover of an accessible compartment is opened or removed for normal use, it is permissible that the opening or removing of other covers of the same accessible compartment requires the use of tools.

6.102.3 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 3.6.110 to 3.6.112, they shall be metal, earthed and provide as minimum degree of protection IP2X.

In this respect it should be noted that:

– a partition or shutter becomes a part of the enclosure if it is accessible in any of the positions defined in 3.6.110 to 3.6.112 and if no door is provided which can be closed in the positions defined in 3.6.109 to 3.6.112;

– if a door is provided which can be closed in the positions defined in 3.6.109 to 3.6.112, the partition or shutter behind the door is not considered to be a part of the enclosure.

6.102.4 Inspection windows

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

They shall be covered by a transparent sheet of mechanical strength comparable to that of the enclosure. Precautions shall be taken to prevent the formation of dangerous electrostatic charges, either by clearance or by electrostatic shielding (e.g. a suitable earthed wire-mesh on the inside of the window).

The insulation between high-voltage live parts and the accessible surface of the inspection windows shall comply with the rated insulation levels U_d and U_p according to 5.3.

6.102.5 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 enclosure is obtained. Such openings may make use of wire mesh or the like provided that it is of suitable mechanical strength.

6.103 High-voltage compartments

6.103.1 General

High-voltage compartments may be of various types, for example:

– air insulated;
– liquid-filled (see 6.103.2);
– gas-filled (see 6.103.2).

High-voltage compartments should also be classified as accessible or non-accessible.

NOTE 1 Only interlock-controlled accessible ~~high-voltage~~ compartments and procedure based accessible compartments are considered when defining the LSC category of a functional unit.

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.

Electrical connections between the main circuit of the assembly and the external conductors (cables or bars) to the electrical network or high-voltage apparatus of the installation shall be made within a high-voltage accessible compartment. This compartment shall be designated as a "connection compartment".

Where other main components (e.g. circuit-breakers, busbars) are contained in the connection compartment, then the designation should primarily remain as the connection compartment.

The connection compartment may be further identified according to the several components enclosed, for example connection/CT, or connection/circuit-breaker compartment. However, for the purposes of LSC categorization, the designation is "connection compartment".

The LSC category can only be assigned to functional units that include a connection compartment. This implies that e.g. a bus-sectionaliser or bus-coupler functional unit will have no LSC category, refer to Figure 8 and Figure 9.

Busbar compartments may extend through several functional units without the need for bushings or other equivalent means. However, in the case of LSC2, LSC2A, LSC2B assemblies

with accessible busbar compartments (refer to 9.101.3), separate compartments shall be provided for each set of busbars, for example in double busbar systems and for sections of switchable or disconnectable busbars.

NOTE 2 The busbar system is not considered as a functional unit.

Parts of the busbar systems, in between two high-voltage compartments of functional units, shall be considered as part of their adjacent compartments if IP2X is ensured for these "in between" parts by the enclosures of both adjacent high-voltage compartments. In case IP2X is not met, a separate compartment shall be defined for these "in-between" parts.

Parts of the busbar at the end of the busbar system shall be considered as part of the adjacent compartment if their length out of the enclosure of the high-voltage compartment is less than 12,5 mm. If this criterion is not met, a separate compartment shall be defined for these busbar extension elements.

6.103.2 Fluid-filled compartments (gas or liquid)

6.103.2.1 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 such that gas-filled compartments are ~~normally~~ filled with a gas that is stable and non-corrosive in the conditions that prevail inside the compartment; since measures to maintain the gas in this condition with only small fluctuations in pressure are fundamental to the operation of the assembly 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.

NOTE 1 The non-corrosive conditions that prevail inside gas-filled compartments are maintained by appropriate measures such as filter material to adsorb humidity and decomposition products, if any.

~~Gas-filled compartments with design pressures higher than 300 kPa (relative pressure) shall be designed according to the pressure requirements of IEC 62271-203.~~

Materials used in the construction of enclosures should be of known and certified minimum physical properties on which pressure tests are based (see 7.103). The manufacturer is responsible for the selection of the materials and the maintenance of these minimum properties, based on certification of the material supplier or tests conducted by the manufacturer, or both.

NOTE 2 See also Annex C.

6.103.2.2 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 filling level~~ the design pressure as defined in this document.

For indoor installations, 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 continuous current. For outdoor installations, other possible influences, for example solar radiation, shall be taken into account.

The design pressure of a compartment ~~shall be at least~~ is equal to the maximum pressure difference between the fluid inside the compartment at design temperature that the fluid used for insulation can reach under specified maximum service conditions, and the surrounding media, like ambient air or insulation fluids in other compartments.

~~In addition to the design temperature~~ Therefore, the design pressure calculation shall also consider:

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.

The design of the fluid-filled compartment shall also take into account the possibility of the occurrence of an internal arc fault.

In normal service, the pressure inside a gas-filled compartment varies from the filling pressure p_{re} with the gas temperature variations, at different service conditions, and possible leaks. Several pressure values shall be coordinated when designing a fluid-filled compartment. An example is shown in Figure E.1.

6.103.2.3 Tightness

The manufacturer shall state the pressure system used and the permissible leakage rate for the fluid-filled compartments (refer to 6.16 and 6.17 of IEC 62271-1:2017). This shall take into account the relative limits fixed in Table 15 of IEC 62271-1:2017 for temporarily increased leakage rates at temperatures other than 20 ºC.

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 pressure exceeds 100 kPa (relative pressure) an indication shall be provided when the pressure at 20 °C has fallen below the minimum functional level (refer to 3.6.114).~~

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

6.103.2.4 Pressure relief of fluid-filled compartments

Where pressure-relief devices or designs are provided, they shall be orientated so as to minimize the danger to an operator during the time that he is performing his 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.~~ Pressure relief devices shall operate with relative pressure above 1,3 times the design pressure. The pressure relief device may be a designed, deliberate weak area of the compartment or a dedicated device, for example a bursting disc.

6.103.3 Partitions and shutters

6.103.3.1 General

A compartment can contain barriers, structures or components that are designed to provide various functions, such as mechanical or dielectrical integrity, but not designed to function as a partition or enclosure.

Partitions and shutters, when accessible in service, shall provide at least the degree of protection IP2X according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

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

Openings in the enclosure of an assembly and in the partitions between compartments accessible during service, through which contacts of removable or withdrawable parts engage fixed contacts, shall be provided with automatic shutters to ensure the protection of persons in any of the positions defined in 3.6.110 to 3.6.112. 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 high-voltage compartment, (e.g. connection compartment is opened, but shutters are located in circuit-breaker compartment). In such situations, verification of the shutter status may require access to the second compartment or provision of an inspection window or reliable indicating device.

If one or more set(s) of fixed contacts can be made accessible through opened shutters (e.g. for maintenance or test purposes), then the shutters shall be provided with means of locking each set independently in the closed position.

If the automatic closing of shutters can be made inoperative in order to retain them in the open position (e.g. for maintenance or test purposes), then it shall not be possible either for the switching device to return to the service position or to close the switching device in the service position, until the automatic operation of the shutters is restored. This can be realized for example by preventing the switching device to return to its service position or by automatic restoration when 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 11.5). Insertion of such a temporary partition shall be possible before the compartment to be opened exposes the high-voltage parts that are intended to be kept energized.

For class PM, partitions and shutters between opened compartments and remaining high-voltage live parts of the assembly shall be metal; otherwise, the class is PI (refer to 3.6.106 to 3.6.108).

6.103.3.2 Metal partitions and shutters

Metal partitions and shutters or metallic parts of them shall be connected to the earthing point provided with a voltage drop of less than 3 V at 30 A (DC).

Discontinuity in the metal partitions and closed metal shutters which may become accessible shall be less than 12,5 mm.

NOTE The word "discontinuity" covers any insulating or non-earthed area, or path, through the partition.

6.103.3.3 Non-metal partitions and shutters

Non-metal partitions and shutters, made or partly made of insulating material, which may become accessible shall meet the following requirements:

a) the insulation between high-voltage live parts and the accessible surface of insulating partitions and shutters shall withstand the test voltages specified in 5.3 of IEC 62271-1:2017 for voltage tests to earth and between poles;

b) the insulating material shall withstand the power-frequency test voltage specified in item a). The appropriate test methods given in IEC 60243-1 [9] should be applied;

c) the insulation between high-voltage live parts and the inner surface of insulating partitions and shutters facing these shall withstand at least 150 % of the rated voltage of the equipment if a separate insulating medium, i.e. gas or liquid, is in-between;

NOTE Solid-insulation embedding high-voltage conducting parts is not considered as a partition.

d) if a leakage current can reach the accessible side of the 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 7.104.3).

6.104 Removable parts

If the assembly incorporates removable parts which may be exchanged, for example fuse-links, then the manufacturer shall provide a reference list.

NOTE 1 For a reference list of fuse-links of switch-fuse combinations, IEC 62271-105 provides further information.

Removable parts for ensuring the isolating distance between the high-voltage conductors shall comply with IEC 62271-102:2018, except for mechanical operation tests (refer to 7.102 and 8.102). 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 62271-102:2018.

Removable parts that are fixed, for example by bolts and/or screws, are not subject to mechanical operation tests according to 7.102.1, if not otherwise specified by the manufacturer.

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

– the isolating distance is visible with the removable part removed;
– in case of a withdrawable part:
  - 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 2 Refer to IEC 62271-102:2018 and also to Annex C.

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 assemblies, the transfer of withdrawable parts to or from 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.

6.105 Provisions for dielectric tests on cables

Assemblies may be designed to allow the testing of cables while they are connected to the assembly. This may be performed either from a dedicated test connection, or from the cable terminations. In both cases the assembly shall have rated cable test voltage(s) as specified in 5.102 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.

6.106 Internal arc fault

Assemblies that satisfy the requirements of this document are designed and manufactured, in principle, to prevent the occurrence of internal arc faults. However, where internal arc classification IAC is assigned, the assembly shall be designed to give a defined level of protection of persons in the event of an internal arc, when the assembly is in normal operating conditions.

Normal operating conditions imply that doors and covers are closed unless opening is necessary to perform switching operations.

If IAC is assigned, then this designation shall be included in the nameplate (refer to 6.11).

Some examples for designations of the IAC classification are given in 9.103.6.

7 Type tests

7.1 General

7.1.1 Basics

Subclause 7.1.1 of IEC 62271-1:2017 is applicable with the following addition:

Components contained in an assembly shall comply with their individual component standards, taking into account Clause 7.

Because of the variety of types, ratings and possible combinations of components, it is not practicable to make type tests with all the arrangements of an assembly. The validity of type tests performed on one test object with a defined set of ratings to other assemblies of the same family with a different set of ratings or different arrangements of components may be evaluated; in that case IEC TR 62271-307 [10] should be applied.

The type tests and verifications comprise:

Mandatory type tests to verify the:

a) rated insulation level of the equipment (see 7.2);
b) measurement of the resistance of circuits (see 7.4);
c) rated continuous current of any part of the equipment and measurement of the resistance of circuits (see 7.5);
d) capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents (see 7.6);
e) making and breaking capacity of the included switching devices (see 7.101);
f) mechanical operation of the included switching devices and removable parts (see 7.102);
g) IP protection code (see 7.7.1);
h) IK protection code (see 7.7.2).

Mandatory type tests, where applicable, to verify the:

i) auxiliary and control circuits (see 7.10);
j) protection of persons against dangerous electrical effects (see 7.104);
k) pressure withstand of gas-filled compartments (see 7.103);
l) tightness of gas- or liquid-filled compartments (see 7.8);
m) IAC classification (see 7.105);
n) electromagnetic compatibility (EMC) (see 7.9);
o) X-radiation level for vacuum interrupters (see 7.11);
p) protection of the equipment against external effects due to weather (see 7.7.1);
q) rated cable test voltages (see 7.2.101).

Optional type tests (subject to agreement between manufacturer and user):

r) tests to evaluate the insulation of the equipment by the measurement of partial discharges (see 7.2.10).

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

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC 62271-1:2017 is applicable.

7.1.3 Information to be included in type-test reports

Subclause 7.1.3 of IEC 62271-1:2017 is applicable with the following addition:

For the test report regarding continuous current tests, refer also to 7.5.101.

For the report regarding internal arc tests, refer to 7.105.6.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2.1 of IEC 62271-1:2017 is applicable.

7.2.2 Ambient air conditions during tests

Subclause 7.2.2 of IEC 62271-1:2017 is applicable.

7.2.3 Wet test procedure

Subclause 7.2.3 of IEC 62271-1:2017 is not applicable.

7.2.4 Arrangement of the equipment

Subclause 7.2.4 of IEC 62271-1:2017 is applicable with the following addition:

Overvoltage protective devices shall be disconnected or removed for the test.

For assemblies using fluid (liquid or gas) for insulation, dielectric tests shall be performed on the test objects filled with the insulating fluid specified by the manufacturer, to the minimum functional level also specified by the manufacturer.

7.2.5 Criteria to pass the test

Subclause 7.2.5 of IEC 62271-1:2017 is applicable with the following modifications:

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

For fluid-filled compartments tested with test bushings that are not part of the assembly, impulses resulting in flashover along the surface of the test bushings are not considered as part of the test series.

7.2.6 Application of the test voltage and test conditions

Subclause 7.2.6 of IEC 62271-1:2017 is applicable with the exception of 7.2.6.2 and with the following additions:

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, they shall cover the following tests:

a) To earth and between phases

The test voltages specified in 7.2.7 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 or the frame and to the earth terminal of the test supply.

If the phase conductors are segregated, only tests to earth shall apply.

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 or test position may result in less favourable field conditions. Under such conditions the tests shall be repeated with such device(s) in those specific positions. However, switching devices do not need to be tested in open position when their component standard does not require to test them in this open position, and removable parts themselves shall not be subjected to these voltage tests whilst they are in the disconnected, test or removed position. The earthing of removable parts in these positions during the tests shall be as in service.

In case specific devices, such as current transformers, cable terminations or overcurrent releases/indicators, could influence the electrical fields, they shall be installed as in service during these tests. For impulse voltage tests, the arrangements according to 7.2.7.3 are allowed. In case of doubt about the most unfavourable arrangement, tests shall be repeated with alternative configurations.

In order to check compliance with the requirements of 6.102.4 and item a) of 6.103.3.3, inspection windows, partitions and shutters of insulating material shall be covered on the side accessible during operation or maintenance, in the most unfavourable situation for the test, with a circular or square metal foil having an area as large as possible but not exceeding 100 cm^2 which shall be connected to earth. In case of doubt about the most unfavourable situation, the tests shall be repeated with different situations. For convenience of testing, subject to agreement between testing station and manufacturer, more than one metal foil may be applied simultaneously, or larger parts of the insulating material may be covered.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in 7.2.7 according to the test procedures as stated in 7.2.6.3 of IEC 62271-1:2017.

The isolating distance could be formed by:

– a disconnector in the open position;

– the distance between the two parts of the main circuit intended to be connected by a withdrawable or removable switching device;

– the sum of the clearances between several open gaps in series.

If, in the disconnected or test position, an earthed metal shutter is interposed between the disengaged contacts to ensure a segregation, the gap between the earthed metal shutter and the live parts shall withstand only the test voltages required to earth according to item a) above.

If there is no segregation between the fixed part and the withdrawable part when an isolating distance is established, the test voltages specified across the isolating distance shall be applied under the following conditions: 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.

c) Complementary tests

In order to check compliance with the requirement of item c) of 6.103.3.3, if applicable, the insulation between the high-voltage live parts and the inside of insulating partitions or shutters shall be subjected to a power-frequency test voltage of 150 % of the rated voltage U_r for 1 min. after covering the inner surface of the partition or shutter facing the live parts by an earthed metal foil as described under a) above.

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

7.2.7.1 General

Subclause 7.2.7.1 of IEC 62271-1:2017 is applicable.

7.2.7.2 Power-frequency voltage tests

Subclause 7.2.7.2 of IEC 62271-1:2017 is replaced by the following provisions:

Assemblies 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. A transformer, a coil, or a similar device normally connected between phases shall be disconnected from the pole stressed with test voltage.

At common value power-frequency voltage tests, one terminal of the test transformer shall be connected to earth and to the enclosure of the assembly.

For isolating distance power-frequency voltage tests, 7.2.6.3 of IEC 62271-1:2017, is applicable, with "frame" to be replaced by "enclosure".

For the special cases considered in 7.2.6.3 of IEC 62271-1:2017, the isolating distance may be tested as follows:

– Preferred method: In this case, neither of the two voltage values applied to the two terminals shall be higher than the rated withstand voltage phase-to-earth;
– Alternative method: The voltage to earth of the frame U_f does not need to be bonded so accurately and the frame may even be insulated from earth.

7.2.7.3 Lightning impulse voltage tests

Subclause 7.2.7.3 of IEC 62271-1:2017 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.

Current transformer secondary windings shall be short-circuited and earthed. Current transformers may have their primaries short-circuited too.

For common value lightning impulse voltage tests, one terminal of the impulse generator shall be connected to earth and to the enclosure of the assembly.

For isolating distance lightning impulse voltage tests, 7.2.6.3 of IEC 62271-1:2017, is applicable with "frame" to be replaced by "enclosure".

7.2.8 Tests of switchgear and controlgear of U_r > 245 kV

Subclause 7.2.8 of IEC 62271-1:2017 is not applicable.

7.2.9 Artificial pollution tests for outdoor insulators

Subclause 7.2.9 of IEC 62271-1:2017 is not applicable.

7.2.10 Partial discharge tests

Subclause 7.2.10 of IEC 62271-1:2017 is applicable with the following additions:

If the test is performed, it shall be according to Annex B.

NOTE It is good engineering practice to carry out a partial discharge type test on a complete functional unit or assembly (where possible).

7.2.11 Dielectric tests on auxiliary and control circuits

Subclause 7.2.11 of IEC 62271-1:2017 is applicable with the following additions:

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

Voltage-limiting devices in the auxiliary and control circuits, if any, shall be disconnected.

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

7.2.12 Voltage test as condition check

Subclause 7.2.12 of IEC 62271-1:2017 is applicable.

7.2.101 Dielectric tests on cable testing circuits

This type test is applicable only to assemblies having one or more rated cable test voltage(s).

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

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

The test voltages defined under a) and b) shall be applied simultaneously. If, during this test, there is segregation between the cable test connections and the busbars, the test voltage on the busbar side may be omitted.

For AC test voltages, the two test voltages shall be in phase opposition.

For AC cable test voltages $U_{ct\ (AC)}$ the duration of the test shall be 1 min. For DC cable test voltages $U_{ct\ (DC)}$, its rated duration shall be kept for each polarity (refer to 5.102.3).

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2017 is not applicable.

7.4 Resistance measurement

7.4.1 Measurement of the resistance of auxiliary contacts class 1 and class 2

Subclause 7.4.1 of IEC 62271-1:2017 is applicable.

7.4.2 Measurement of the resistance of auxiliary contacts class 3

Subclause 7.4.2 of IEC 62271-1:2017 is applicable.

7.4.3 Electrical continuity of earthed metallic parts test

Subclause 7.4.3 of IEC 62271-1:2017 is applicable.

7.4.4 Resistance measurement of contacts and connections in the main circuit as a condition check

Subclause 7.4.4 of IEC 62271-1:2017 is applicable with the following addition:

The maximum acceptable increase of resistance for individual switching devices within the assembly after mechanical and/or making and breaking tests is defined in the corresponding switching device standard of the IEC 62271 series.

7.5 Continuous current tests

7.5.1 Condition of the test object

Subclause 7.5.1 of IEC 62271-1:2017 is applicable.

7.5.2 Arrangement of the equipment

Subclause 7.5.2 of IEC 62271-1:2017 is applicable with the following modifications:

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.

In case of functional unit(s) incorporating fuses, the test shall be performed with the fuse-links generating the highest power dissipation from the reference list provided by the assembly manufacturer.

7.5.3 Test current and duration

7.5.3.1 Test on main circuit

Subclause 7.5.3.1 of IEC 62271-1:2017 is applicable with the following modifications:

Each functional unit of the assembly shall be tested once at its rated continuous current, with the adjacent functional units (if any) at the maximum continuous current that the electrical scheme of the assembly and the rated continuous current of each functional unit allows. Alternatively, each functional unit may be individually tested for its rated continuous current with either heat insulation or heaters at the sides reproducing the same conditions as with the preceding testing procedure.

When testing with the fuse-links generating the highest power dissipation, the continuous current indicated on the list of fuse-links provided by the assembly manufacturer shall be applied.

7.5.3.2 Test of the auxiliary and control equipment

Subclause 7.5.3.2 of IEC 62271-1:2017 is applicable with the following exception:

This test need not be performed on circuits and components of auxiliary and control equipment which already have demonstrated their operation at ambient temperature limits during mechanical tests with the high-voltage switching devices installed inside the assembly, according to the relevant component standard, for example IEC 62271-100, IEC 62271-102 or IEC 62271-103.

7.5.4 Temperature measurement during test

Subclause 7.5.4 of IEC 62271-1:2017 is applicable with the following modifications to 7.5.4.2:

The temperature of the test conductors shall be measured at the point where they leave the enclosure and at a distance of 1 m externally along the temporary feeding connections. The temperature difference shall not exceed 5 K. However, in case this temperature difference exceeds 5 K, the test may be considered as valid if the above indicated point at 1 m from the assembly is the hottest and all criteria to pass the test defined in 7.5.6 are fulfilled.

7.5.5 Resistance of the main circuit

Subclause 7.5.5 of IEC 62271-1:2017 is applicable with the following addition:

The measured resistance, before the continuous current test, across the complete main circuit of an assembly is indicative of the proper condition of the current path. This measured resistance shall be the reference for the routine test (refer to 8.4).

7.5.6 Criteria to pass test

Subclause 7.5.6 of IEC 62271-1:2017 is applicable with the following additions to 7.5.6.1:

The temperature rise of assemblies containing components which are subject to individual component standards shall not cause these components to exceed their temperature limits as permitted in their relevant standard.

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.

7.5.101 Test report

In addition to the requirements of 7.1.3, in case the test object is equipped with high-voltage fuses, the following fuse information shall be included in the test report:

- manufacturer;
- type designation;
- rated voltage and rated current;
- power (in watts) dissipated by each individual (1-phase) fuse-link just before the end of the test period.

NOTE 1 The power dissipated by the fuse-link is defined by the product of the applied AC continuous test current (RMS value) and the measured steady voltage drop across the fuse-link.

NOTE 2 The voltage drop is measured on the fuse-link contacts as close as possible to the point of contact with the immediate mating contact piece.

7.6 Short-time withstand current and peak withstand current tests

7.6.1 General

Subclause 7.6.1 of IEC 62271-1:2017 is applicable with the following additions:

a) Test on main circuits

Main circuits of assemblies 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 assembly with all associated components influencing the performance or modifying the short-circuit current.

Parts of the main circuits which incorporate current-limiting fuses do not need to be tested if one of the conditions below is fulfilled:

– the making and breaking tests of the switching function incorporating the fuses have been performed within the assembly;

NOTE 1 An example of switching function incorporating current-limiting fuses is a switch-fuse combination.

– breaking tests of the fuses, when the fuses are not part of a switching function, have been performed within the assembly;

– a short-time withstand current test, with a solid metal link replacing the fuse-link, demonstrating that both the applied peak current and resulting thermal effects (i.e. Joule integral I^2t) are equal to or higher than, those which would be obtained with fuses at the rated voltage, has been performed within the assembly.

In all cases, the performed tests shall at least cover the situations of maximum breaking current (up to I_k and I_p of the branch of the assembly incorporating current-limiting fuses) and of maximum let-through I^2t for the fuses which can be used within the assembly according to the reference list provided by the manufacturer.

NOTE 2 The maximum let-through I^2t is generally obtained with a lower prospective current than I_k.

Connections to auxiliary devices (such as voltage transformers, auxiliary transformers, surge arresters, surge capacitors, voltage detection devices, and similar items) are not part of the main circuit (refer to 3.5.105).

b) Tests on earthing circuits

Earthing devices, earthing conductors, earthing connections and other conductive parts forming part of the earthing circuit of an assembly shall be tested to verify their capability to withstand their rated short-time and peak withstand currents (I_k, I_p, t_k and I_{ke}, I_{pe}, t_{ke} – as applicable). They shall be tested as installed in the assembly with all associated components influencing the performance or modifying the short-circuit current.

The short-time withstand current and peak withstand current tests shall be carried out on the short-circuiting parts of each earthing circuit according to the number of phases of the corresponding earthing device (I_k, I_p, t_k). Additionally, single-phase tests shall be performed on all parts of the earthing circuit that are designed to provide the connection between the earthing device and the earthing point provided, at the rated short-time and peak withstand currents (I_{ke}, I_{pe}, t_{ke}).

When there are removable earthing devices, the earthing connection(s) between the fixed part (of the assembly) and the removable earthing device shall be tested at the rated short-time and peak withstand currents (I_k, I_p, t_k and I_{ke}, I_{pe}, t_{ke} – as applicable). The current shall flow along the earthing conductor between the fixed part and the earthing point of the removable part. Additionally, where the earthing device in the assembly can be operated in alternative positions to the service position, the test shall be repeated for all alternative positions.

Each test shall be preceded by a no-load operation of the mechanical switching device(s) and by measurement of the resistance of the main circuit according to 7.4.4. The no-load opening operation shall be carried out at the rated value of the supply voltage in the case of power

operated devices and the force/torque shall be measured in the case of dependent manually operated devices.

Earthing switches and earthing circuits are excluded from resistance measurement.

7.6.2 Arrangement of the equipment and of the test circuit

Subclause 7.6.2 of IEC 62271-1:2017 is not applicable.

The circuits of the test object shall be selected in such a way that the most onerous conditions are obtained concerning the maximum lengths of unsupported conductors, configuration of the conductors and connections within the equipment, and the assigned rated values. In the case of assemblies incorporating the same switching device at several locations, it also shall be checked that the most onerous location of the switching device is tested.

The test connections to the terminals of the assembly 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 assembly shall be in accordance with the manufacturer's instructions reference.

The short-time withstand current and peak withstand current tests shall be carried out according to the number of phases of the circuit under test. However, each earthing circuit shall be tested with its number of phases at its I_k, I_p and t_k, and tested single-phase at its I_{ke}, I_{pe} and t_{ke} up to the earthing point provided on the test object. These tests may be performed on different test samples. Parts of the earthing circuit already satisfactorily tested may be replaced between tests on different earthing circuits.

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 the rated voltage of the assembly, except if the test set-up at a lower voltage results in mechanical and thermal effects that are equal to, or higher than, those with the incorporated current-limiting device at rated voltage. Refer to 7.6.1 a) for further details on fuse-link selection, and accepted alternatives to demonstrate this performance.

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

NOTE The definition of self-tripping circuit-breakers is provided in 3.4.113 of IEC 62271-100:2021.

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

The test arrangement shall be noted in the test report.

7.6.3 Test current and duration

Subclause 7.6.3 of IEC 62271-1:2017 is applicable with the following additions:

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

The rated duration for these tests will be t_k or t_{ke}, whichever is applicable for the tested circuit.

7.6.4 Conditions of the test object after test

Subclause 7.6.4 of IEC 62271-1:2017 is applicable with the following additions:

The maximum acceptable increase of resistance for the complete main circuit of an assembly as condition check is considered to be satisfactory if this resistance increase does not exceed 20 % of the value measured before the test. If the resistance increase exceeds 20 % then a continuous current test (see 7.5) is applicable to determine if the test object can carry its rated continuous current.

After the test on each earthing circuit, some deformation and degradation of the earthing devices, earthing conductors, earthing connections and other conductive parts forming part of the earthing circuit 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 (DC) to the earthing point provided. The voltage drop shall be lower than 3 V.

7.7 Verification of the protection

7.7.1 Verification of the IP coding

Subclause 7.7.1 of IEC 62271-1:2017 is applicable with the following additions:

For verification of the IP coding, the service condition is with all doors and covers closed, no matter how they are expected to be locked or not.

Accessible partitions and shutters, as defined by the manufacturer, shall be verified on IP2X.

7.7.2 Verification of the IK coding

Subclause 7.7.2 of IEC 62271-1:2017 is applicable with the following addition:

For verification of the IK coding, the service condition is with all doors and covers closed, no matter how they are expected to be locked or not.

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2017 is applicable with the following additions to 7.8.1:

The tightness of each representative tight compartment shall also be tested once at the maximum ambient air temperature of the specified service conditions as defined in Clause 4 of IEC 62271-1:2017. The leakage rate shall stay within the limits defined in Table 15 of IEC 62271-1:2017.

For a defined type of switchgear and controlgear, a tight compartment design is considered to be validated if all types of sealings for a specific design are tested at least once on representative compartments.

These tests may be performed during other tests at temperature limits (if any) as specified in component standards.

7.9 Electromagnetic compatibility tests (EMC)

Subclause 7.9 of IEC 62271-1:2017 is applicable with the following addition to 7.9.1.2:

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

7.10 Additional tests on auxiliary and control circuits

7.10.1 General

Subclause 7.10.1 of IEC 62271-1:2017 is applicable with the following addition:

Where applicable, the tests under 7.10 shall be performed on a typical lay-out of the assembly, based on the standard wiring rules of the manufacturer.

7.10.2 Functional tests

Subclause 7.10.2 of IEC 62271-1:2017 is not applicable.

NOTE Functional tests on auxiliary and control circuits are performed as routine tests, refer to 8.3.2.

7.10.3 Verification of the operational characteristics of auxiliary contacts

Subclause 7.10.3 of IEC 62271-1:2017 is applicable with the following addition:

This subclause is not applicable to the auxiliary contacts already tested according to their own standard.

7.10.4 Environmental tests

Subclause 7.10.4 of IEC 62271-1:2017 is applicable with the following limitations:

– tests do not apply for indoor assemblies operated under normal service conditions as defined by 4.1.2 of IEC 62271-1:2017;
– when the tests as stated in 7.10.4 of IEC 62271-1:2017 have been performed on the separate components of a representative auxiliary and control circuit, no further environmental tests are needed.

7.10.5 Dielectric test

Subclause 7.10.5 of IEC 62271-1:2017 is applicable.

7.11 X-radiation test for vacuum interrupters

Subclause 7.11 of IEC 62271-1:2017 is applicable.

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

7.101 Verification of making and breaking capacities

7.101.1 General

Switching devices forming part of the main circuit and earthing switches of assemblies 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 assembly with all associated components that may influence the performance, such as connections, supports, provisions for venting. These tests are not necessary if making and breaking tests have been performed on the switching devices installed in assemblies with identical or more onerous conditions.

NOTE In determining which associated components are likely to influence the performance, the following can be relevant: 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 influence can be quite negligible. IEC TR 62271-307 lists the relevant design parameters that are considered to establish the same or less onerous conditions.

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 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 7.101.2 and 7.101.3 below shall be repeated in each of the compartments where these switching devices are installed;

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.

7.101.2 Test requirements for main switching devices

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

– IEC 62271-100:2021: test duties T100s, T100a, and critical current tests (if any) also taking into account the requirements of 6.103.4 of that standard for the test connection arrangement, where applicable. For circuit-breakers that are already type tested in alternative configurations for both k_{pp} = 1,5 and 1,3, then T100s and T100a only have to be demonstrated for k_{pp} = 1,5;

– IEC 62271-103:2021: Test duty TD_{load2} (10 CO operations). Where the switch has a rated short-circuit making capacity, the 10 CO operations of TD_{load2} shall be followed by test duty TD_{ma} according to class E1, E2 or E3, as applicable;

– IEC 62271-105:2021: Test duties TD_{lsc} and the highest value of $TD_{ltransfer}$ and TD_{lto};

– IEC 62271-106:2021: Verification of coordination with SCPDs;

– IEC 62271-107:2019: Test duties TD_{lr}, and TD_{lsc} and TD_{lto};

– IEC IEEE 62271-37-013:2015: Test duties 1 and 2.

Refer to 7.4.4 for maximum allowed resistance increase along the main circuit after making and breaking tests.

7.101.3 Test requirements for earthing function

If the earthing function has an assigned class E1 or E2, it shall be tested in accordance with the requirements of IEC 62271-102:2018 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.

If the class E1 or E2 earthing function is performed by the main switching device in combination with a class E0 earthing switch, then the test requirements shall be the same as for a combined function earthing switch as defined in 7.101 of IEC 62271-102:2018. In this case the requirements of 7.101.8 and 7.101.9 of IEC 62271-102:2018 apply to both the class E0 earthing switch and the main switching device.

7.102 Mechanical operation tests

7.102.1 Switching devices and removable parts

All switching devices not previously tested as mounted in the assembly, shall be operated 50 times C-O, mounted in the assembly. Test conditions and criteria to pass the test are identical to the ones defined on each corresponding switching device standard for mechanical tests.

If a removable part is intended to be used as a disconnector, then the mechanical endurance shall be in accordance with IEC 62271-102:2018. Otherwise, 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 remain lower than 150 % of that required for the first operation.

The reliable operation of 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, shall be checked.

For functional units including several switching devices, the operations may be performed as part of a sequence of operations involving all these switching devices. If the insertion/removal of a removable part is involved in the sequence, the number of such sequences should be limited to 25. Any operations not included in this sequence should be separately tested.

In the case of manually operated equipment, the normal manual operation handle shall be used to perform the tests.

7.102.2 Mechanical and electromechanical interlocks and locking devices

The interlocks and locking devices shall be set in all positions intended to prevent:

– the operation of the switching devices;
– the access to operation interfaces;
– the insertion or withdrawal of removable parts.

The following tests shall be made in order to attempt to defeat the interlocks and locking devices:

a) 10 attempts to open any interlocked or locked door or cover;
b) 10 attempts to access or engage the operation interface, when access or engagement is prevented due to an interlocking or locking device (shutter, selector lever, etc.);
c) 20 attempts to operate the switching devices manually, when the operation interface is accessible;
d) 10 attempts to operate the switching device manually in the wrong direction shall be carried out in addition to, but anywhere in, the above sequence of 20 attempts;
e) 10 attempts to insert and 10 attempts to withdraw the removable parts;
f) in case of electrical interlocks, switch off the auxiliary power supply and carry out one attempt of items a) to e);
g) in case of automatic closing of shutters that can be made inoperative in order to retain them in the open position: check that the switching device cannot be returned to the service position before the automatic operation of the shutters is restored (refer to 6.103.3.1).

The normal manual operation handle (if any) shall be used to perform these tests.

During the tests, the following prospective force or torque shall be applied:

– force of 400 N on handles of doors, covers and actuators of drive mechanisms with the exceptions given below;
– force of 750 N on handles of drive mechanisms with an interlock or lock blocking the operating shaft;
– force of 100 N on handles of shutters, selectors, etc. preventing access to the operation interface;
– force of 100 N on small linear actuators like push-button, plunger, etc.;
– torque of 3 Nm on small rotating actuators like knobs.

The force shall be applied ~~halfway along the length~~ at the midpoint of the gripping part of the handle or actuator~~.~~ with the following considerations:

– For handles consisting of one or more levers, the gripping part shall be defined by the manufacturer before testing. In this case, two different scenarios are considered:
  - if intended for gripping with one hand, the gripping part shall not extend more than 100 mm from the end of the lever;
  - if intended for gripping with two hands next to each other, the gripping part shall not extend more than 200 mm from the end of the lever.
– For handles where the lever is extensible or sliding, the lever shall be at the longest possible length, and the full force shall be applied to only one of the gripping parts of the lever(s), if more than one exists.

Where operating handles and actuators incorporate a feature which limits the transmitted force or torque, the maximum test force or torque shall be limited to that which can be applied by the handle or actuator, provided that the handle or actuator is not interchangeable with other handles or actuators.

No adjustment shall be made to the switching devices, removable parts or interlocks during these tests.

The integrity of sliders or other devices preventing access to the operation interface shall be verified in accordance with 7.7.2 (verification of the IK coding).

Where mechanical interlocks are designed to prevent the operation of motorized switching devices, the following additional tests shall be performed using the motor:

– 20 attempts to operate the switching devices;
– 10 attempts to operate the switching device in the wrong direction shall be carried out in addition to, but anywhere in, the above sequence of 20 attempts.

110 % of the rated supply voltage of auxiliary circuits shall be applied for a duration of 2 s.

The interlocks are considered to be satisfactory if:

a) the switching devices cannot be operated;
b) access to the interlocked compartments is prevented;
c) the insertion and withdrawal of the removable parts are prevented;
d) the switching devices, removable parts and the interlocks are still operative and the effort to operate them before and after the tests, does not differ from the maximum hand operating forces (manual operation) or peak energy consumption (motor operation) by more than 50 %. In case of the test with 750 N, damage is acceptable, provided that the interlock still prevents operation.

NOTE These tests can be performed as part of the mechanical operations test sequence.

7.103 Pressure withstand test for gas-filled compartments

7.103.1 Pressure withstand test for gas-filled compartments with pressure relief devices

~~Each design of a gas-filled compartment with design pressure lower than or equal to 300 kPa (relative pressure) shall be subjected to a pressure test according to the following procedure:~~

~~– adjacent compartments (if any) shall be at atmospheric pressure if the manufacturer's instructions reference allow for maintenance of that compartment. Alternatively, they may be evacuated, if allowed by the manufacturer;~~

~~NOTE 1 The test is intended to demonstrate the over-pressure behaviour under service conditions;~~

~~NOTE 2 The design pressure (relative pressure) already considers the situation of adjacent compartment evacuated, if allowed by the manufacturer.~~

~~– the relative pressure shall be increased in order to reach a value of 1,3 times the design pressure of the compartment for a period of 1 min. The pressure relief device shall not operate;~~

~~– then the relative pressure shall be increased up to a maximum value of three times the design pressure. It is acceptable that the pressure relief device may operate, as designed by the manufacturer, below this value. This opening pressure shall be recorded in the type test report. After the test, the compartment may be distorted, but the compartment shall not rupture;~~

~~– visual inspection of the orientation of the pressure relief device shall be made to assess the direction of escaping gases.~~

~~Gas-filled compartments with design pressures higher than 300 kPa (relative pressure) shall be in accordance with the testing requirements of IEC 62271-203.~~

Each design of a gas-filled compartment equipped with its pressure relief devices(s) shall be subjected to pressure tests as follows:

– Adjacent compartments (if any) shall be set at a pressure not higher than the minimum functional pressure of those compartments. If the manufacturer's instructions reference allow for maintenance of those compartments, they shall be at atmospheric pressure. Alternatively, they even may be evacuated, if allowed by the manufacturer.

NOTE 1 This test configuration covers the over-pressure behaviour under intended service conditions.

NOTE 2 The design pressure (relative pressure) calculation already considers the situation of adjacent compartment evacuated, if allowed by the manufacturer.

– The ambient temperature shall be between 15 °C and 30 °C.

NOTE 3 The temperature range is in accordance with ISO 4126-2.

– For all the following pressure tests, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min in order to reach a value of 1,3 times the design pressure of the compartment for a period of 1 min. The pressure relief device shall not operate and the compartment shall not show signs of distress or any distortion likely to affect the operation of the assembly.

– To determine the highest possible value at which the pressure relief device operates, two possible scenarios shall be considered:

  - if no certificate is available for the pressure relief device (for example, in case of integral pressure relief devices), the operating pressure of the pressure relief device shall be verified by testing 5 samples of the pressure relief on the specific compartment design;
  - if a certificate according to ISO 4126-2 for the pressure relief device is available for the range of service temperatures and up to the design temperature, it shall be verified that the operating pressure is in the range given by the certificate by a single test on the specific compartment design.

– For both scenarios, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to the pressure relief device operates, as designed by the manufacturer.

  - The opening pressure(s) shall be recorded in the type test report.
  - A visual inspection of the orientation of the pressure relief device should be performed. The direction of escaping gases should be indicated in the test report.

– Then, a verification of the safety margin of the compartment with respect to the pressure relief operation shall be performed as follows:

  - the pressure relief device shall be blocked or reinforced without impacting the withstand pressure of the compartment;

- then, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to the highest value where the pressure relief would operate (by certificate or test mentioned above) multiplied by a safety factor. Two possible cases shall be considered:
  - if a certificate is available for the pressure relief device for the range of service temperatures and up to the design temperature, the applied safety factor to the upper value of operation given by the certificate shall be 1,1;
  - if no certificate is available for the pressure relief device (for example, in case of integral pressure relief devices), the highest opening pressure recorded in the 5 previous tests is taken and the applied safety factor shall be 1,5.
- the test pressure level shall be maintained for 1 min;
- the compartment may be distorted, but it shall not rupture during the test.

7.103.2 Pressure withstand test for gas-filled compartments without pressure relief devices

~~Each design of a gas-filled compartment shall be subjected to a pressure test according to the following procedure:~~

~~– the adjacent compartments (if any) shall be at atmospheric pressure. Alternatively, they may be evacuated, if allowed by the manufacturer;~~

~~– The relative pressure shall be increased up to three times the design pressure of the compartment for 1 min. After the test, the compartment may be distorted, but the compartment shall not rupture.~~

~~Gas-filled compartments with design pressures higher than 300 kPa (relative pressure) shall be in accordance with the testing requirements of 6.103 of IEC 62271-203:2011.~~

~~NOTE The test is intended to verify the safety margin for possible overpressures under service conditions.~~

Each design of a gas-filled compartment without pressure relief device shall be subjected to a pressure test according to the following procedure:

– Adjacent compartments (if any) shall be set at a pressure not higher than the minimum functional pressure of those compartments. If the manufacturer's instructions reference allow for maintenance of those compartments, they shall be at atmospheric pressure. Alternatively, they even may be evacuated, if allowed by the manufacturer.

  NOTE 1 This test configuration covers the over-pressure behaviour under intended service conditions.

  NOTE 2 The design pressure (relative pressure) calculation already considers the situation of adjacent compartment evacuated, if allowed by the manufacturer.

– The ambient temperature shall be between 15 °C and 30 °C.

– The relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to three times the design pressure of the compartment, except for those with cast aluminium walls with design pressure above 300 kPa where the upper value shall be five times the design pressure. The test pressure level shall be maintained for 1 min. After the test, the compartment may be distorted but it shall not rupture.

7.104 Tests to verify the protection of persons against dangerous electrical effects

7.104.1 General

Subclause 7.104 is applicable to non-metallic partitions and shutters intended for protection from effects of live parts. When these partitions contain bushings, tests shall be carried out under the appropriate conditions, i.e. with the primary parts of the bushings disconnected and earthed.

Solid-insulation embedded high-voltage parts that are intended to remain live when accessing the high-voltage compartment shall be tested according to 6.104 of IEC 62271-201:2014.

7.104.2 Dielectric tests

a) The insulation between high-voltage live parts and the accessible surface of insulating partitions and shutters shall withstand the rated withstand voltages specified in 7.2.7.1 for voltage tests to earth and between poles. For the test set-up, refer to item a) of 7.2.6.

b) A representative sample of the insulating material shall withstand the power-frequency test voltage specified in item a) above. The appropriate test methods given in IEC 60243-1 [9] should be applied.

c) The insulation between high-voltage live parts and the inner surface of insulating partitions and shutters facing these shall be tested at 150 % of the rated voltage of the equipment for 1 min. For the test, the inner surface of the partition or shutter shall be earthed by applying a conductive layer of at least 100 cm^2, at the most onerous point. The test set-up shall be as specified in item a) of 7.2.6.

7.104.3 Measurements of leakage currents

When an assembly contains insulating partitions or insulating shutters, the following tests shall be made in order to check compliance with the requirement of item d) of 6.103.3.3.

The main circuit shall, at the discretion of the manufacturer, be connected either to a three-phase supply of power-frequency voltage equal to the rated voltage of the assembly, with one phase connected to earth, or to a single-phase supply of a voltage equal to the rated voltage, the live parts of the main circuit being connected together. For three-phase tests, three measurements shall be made with the different phases of the supply successively connected to earth. In the case of single-phase tests, only one measurement is necessary.

A metal foil shall be placed in the most unfavourable situation for the test on the accessible surface of the insulation providing the protection against contact with live parts. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations.

The metal foil shall be approximately circular or square, having an area as large as possible but not exceeding 100 cm^2. The enclosure and the frame of the assembly shall be earthed. The leakage current flowing through the metal foil to earth shall be measured with the insulation dry and clean.

The value of the leakage current measured shall not exceed 0,5 mA. If, as indicated in item d) of 6.103.3.3, the continuous path over insulating surfaces is broken by small gaps of gas or liquid, such gaps shall be shorted out electrically. If these gaps are incorporated to avoid the passage of the leakage current from live parts to accessible parts of insulating partitions and shutters, the gaps shall withstand the test voltages specified in 7.2.7.1 for voltage tests to earth and between poles.

It is not necessary to measure leakage currents if earthed metal parts are arranged in an appropriate manner to ensure that leakage currents cannot reach the accessible parts of the insulating partitions and shutters.

7.105 Internal arc test

7.105.1 General

The test is applicable to assemblies for which an internal arc classification has been assigned, covering the event of an arc fault within the enclosure or within components having housings which form part of the enclosure in normal operating conditions. The internal arc test makes allowance for effects acting on all parts of the enclosure, such as internal overpressure, thermal effects of the arc or its roots, the effects of ejected hot gases and glowing particles.

7.105.2 Test conditions

The test shall be carried out with the assembly in the following conditions:

– the position of high-voltage switching devices and withdrawable parts is set to realize the supply circuit according to A.5.1. All other equipment, for example measuring instruments and monitoring equipment shall be in the position as it is in normal service;

– all covers and doors of the assembly shall be closed and correctly secured. However, in case of accessibility type A, if any cover has to be removed and/or any door has to be opened to perform switching operations, the internal arc test shall be carried out with the cover and/or door removed;

– if handle flaps of switching devices do not automatically close after removing the handle, the internal arc test shall be performed with handle flaps in open position.

Every high-voltage compartment of representative functional units of the assembly shall be tested. More than one test object may be necessary to perform all the internal arc tests.

Compartments which are protected by type-tested current-limiting fuses shall be tested with the fuse type that causes the highest cut-off current (let-through current). The actual duration of the current flow will be controlled by the fuses. The tested compartment will be designated as 'fuse-protected'. The tests shall be performed at the rated voltage U_r.

Any device (e.g. protection relay) that can automatically trip the circuit before the end of the prospective duration of the test shall be made inoperative during the test. If compartments or functional units are equipped with devices intended to limit the duration of the arc itself by other means (e.g. by transferring the current to a metallic short-circuit), they shall be made inoperative during the test. However, if the manufacturer declares that these devices are an integral part of the design of the compartment or assembly which prevents to make them inoperative without modification of the construction of the compartment or the enclosure, the relevant compartment of the assembly may be tested with the device operative; but this compartment shall be qualified according to the actual duration of the arc. The test current shall be maintained for the rated short-circuit duration of the main circuit.

NOTE 1 For possible measures to mitigate the effects of internal arcs, refer to Cigré Technical Brochure 686 [11].

~~If, during the test, an arc ignites in other non-previously arc-tested compartment(s) of the same test object, the test shall be regarded as valid only for the compartment where the arc was initiated. The other affected compartment(s) shall be (or have been) tested for at least the number of phases involved in this take-over ignition.~~

If, during the test, an arc ignites in another already arc-tested compartment of the same test object (see 7.105.3), the test is not valid. However, if during the test, an arc ignites in a non-previously arc-tested compartment(s) of the same test object, the test shall be regarded as valid for the compartment where the arc was initiated, under the condition that it can be proven that the ignition was the consequence of design construction, as declared by the manufacturer before the test. Examples of such design constructions are:

– a lower short-circuit withstand of part of the circuit, upstream in the current path from the compartment under test;

– burn-through, or opening of pressure relief flaps, to another compartment.

The manufacturer's declaration shall be referred to in the test report.

The other affected compartment(s) shall be (or shall have been) tested with the point of initiation as required in A.5.2.1. The number of phases to be tested shall be in accordance with A.5.2.1 and Table A.1 provided that the arc initiation involves at least the number of phases involved in this take-over ignition.

NOTE 2 Reason for not accepting the test result in case of transfer to a compartment that was already arc-tested, is that the test result can be influenced by the contamination in that compartment.

7.105.3 Arrangement of the equipment

The equipment shall be arranged as follows:

– the test object shall be fully equipped. Mock-ups of internal components are permitted provided they have the same volume and external material as the original items and they do not affect the main and earthing circuits;

– tests shall be performed on all types of functional units that may be combined into an assembly, as stated by the manufacturer regarding the different possible assembly lay-outs. The following applies:

  - in case of assemblies consisting of extensible (modular) functional units, the test object shall consist of two functional units connected together as in service, unless the manufacturer specifies a different minimum number of functional units;
  - if by design of the assembly, a type of functional unit is not intended to be used as an end unit under service conditions, for its test, it shall be configured in the assembly as close as possible to the lateral side – furthest away from the wall of the room simulation, in an arrangement of more than two functional units;
  - in case of assemblies with at least one high-voltage compartment belonging to more than one functional unit (e.g. several main switching devices in one compartment), the test object shall consist of functional units where the shared high-voltage compartment is complete;
  - the tests shall be made in all high-voltage compartments of a functional unit, as close as possible to the lateral side – furthest away from the wall of the room simulation;
  - in case of assemblies having functional units that contain identical high-voltage compartments with the same internal arc test conditions, one test on this type of compartment is sufficient, provided that the test object was placed as close as possible to the lateral side – furthest away from the wall of the room simulation, as stated by the manufacturer regarding the different possible assembly lay-outs;

– the test object shall be earthed at the earthing point provided;

– tests shall be carried out on compartments not previously subjected to arcing, or, if subjected, being in a condition which does not affect the result of the test;

– in case of fluid-filled compartments (other than SF_6) the test shall be made with the original fluid at its filling pressure (±10 % of the relative pressure) for insulation;

– for environmental reasons, it is recommended to replace SF_6 with air at the filling pressure for insulation and/or switching (±10 % of the relative pressure).

NOTE Test results with air instead of SF_6 are considered to be representative.

7.105.4 Test procedure

The method to verify the internal arc classification is defined in Clause A.5.

7.105.5 Criteria to pass the test

IAC classification according to the relevant type of accessibility, is demonstrated for the assembly if the following criteria are met:

Criterion No. 1

Correctly secured doors and covers do not open. Deformations are accepted, provided that no part comes as far as the position of the indicator mounting frames or the walls (whichever is the closest) on every side and no openings with dimensions larger than 50 mm occurred in the classified sides up to a height of 2 000 mm. The assembly does not need to comply with its IP code after the test.

To extend the acceptance criterion to an installation mounted closer to the wall than tested, two additional conditions shall be met:

– the permanent deformation is less than the intended distance to the wall;

– exhausting gases are not directed to the wall.

Criterion No. 2

– no fragmentation of the enclosure occurs;

– no ejection of fragments or of other parts of the assembly of an individual mass of 60 g or more occur;

– objects of an individual mass of 60 g or more falling to the floor in the immediate vicinity of the assembly are accepted (in the case of accessible sides, this means between the assembly and the indicator rack).

Criterion No. 3

Arcing does not cause holes by burning through in the classified sides up to a height of 2 000 mm.

NOTE 1 Holes in the enclosure which are created after the duration of the test by other effects than burning through, are disregarded.

Criterion No. 4

Indicators do not ignite during the test and within 1 s after the current duration. If indicators have been ignited after 1 s after the current duration and if proof is established of the fact that the ignition was caused by glowing particles rather than hot gases, the assessment criterion has also been met. Pictures taken by high-speed cameras, video or any other suitable means should be used by the test laboratory to establish evidence.

Indicators ignited as a result of paint or stickers burning are also excluded.

NOTE 2 It is assumed that the physical dimensions of the test laboratory are large enough to prevent hot gas reflections towards the indicators from surfaces not belonging to the room simulation (e.g. from other walls or measuring equipment).

Criterion No. 5

The enclosure remains connected to its earthing point. Visual inspection is generally sufficient to assess compliance. In case of doubt, the continuity of the earthing connection shall be checked (refer to 7.6.4).

7.105.6 Test report

In addition to 7.1.3 the following information shall be included:

– description of the test object with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the test object to the floor and/or to the walls;

– the distance between the upper part of the test object and the ceiling of the room or building. For this purpose, the manufacturer shall state the point of the assembly from which this distance is measured;

NOTE Because the distance between the upper part of the assembly and the ceiling under internal arc test conditions can be different from the distance under installation conditions, the information in the test report is about the validity of the test results regarding the ceiling height for installation.

– point and method of initiation of the internal arc fault;

– drawings of test arrangement (room simulation, test object and mounting frame of indicators) with respect to the type of accessibility (A or B), classified sides (F, L or R) and installation conditions;
– applied voltage and frequency;
– for the prospective and/or test current (refer to A.4.3):
  1) RMS value of the AC component during:
     • the first three half-cycles;
     • the last three half-cycles;
  2) highest peak value (actual and/or prospective);
  3) average RMS value of the AC component over the actual duration of the test;
  4) duration of arc fault current;
  5) prospective RMS value and duration of the test current.
– oscillogram(s) showing currents and voltages;
– optionally, total arc energy, peak arc power;
– optionally, measurement of pressure in compartments;
– assessment of the test results, including a record of the observations in accordance with 7.105.5 and observations regarding compartments where take-over ignition took place (if any);
– other relevant remarks.

7.105.7 Extension of validity of test results

The validity of the results of a test carried out in a functional unit of a particular metal-enclosed design of assembly may be extended to another one (refer to 7.1.1 and to IEC TR 62271-307:2015) provided that the original test was more onerous and this other functional unit may be considered as similar to the tested one in the following aspects:

– dimensions;
– structure and strength of the enclosure;
– architecture of the partition;
– performance of the pressure relief device, if any;
– insulation system;
– physical influences (pressure rise, gas flow and thermal effects).

8 Routine tests

8.1 General

Subclause 8.1 of IEC 62271-1:2017 is applicable, with the following additions:

– partial discharge measurement (if applicable): 8.101;
– mechanical operation tests: 8.102;
– pressure tests of gas-filled compartments (if applicable): 8.103;
– tests after erection on site: 8.104;
– measurement of fluid conditions after filling on site (if applicable): 8.105.

8.2 Dielectric test on the main circuit

Subclause 8.2 of IEC 62271-1:2017 is applicable, with the following additions and exceptions:

The power-frequency voltage test shall be performed according to the requirements in 7.2.7.2. The test voltage specified in 7.2.7.1 for U_d, common value, from column 2 of Tables 1 and 2 of IEC 62271-1:2017, shall be applied, connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply, with the other phase conductors connected to earth and the continuity of the main circuit ensured (e.g. by closing the switching devices or otherwise).

The test voltage may be applied at higher than the rated frequency in order to avoid the disconnection of voltage transformers.

Overvoltage protective devices shall be disconnected or removed during the test.

8.3 Tests on auxiliary and control circuits

8.3.1 Inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams

Subclause 8.3.1 of IEC 62271-1:2017 is applicable.

8.3.2 Functional tests

Subclause 8.3.2 of IEC 62271-1:2017 is replaced by:

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 assembly.

Functional tests as specified in the relevant IEC component standards shall be performed on auxiliary and control circuits of each component, subassembly or after mounted on the assembly.

Additionally, all existing auxiliary and control circuits (including electrical interlocks) shall be verified on their proper operation in conjunction with the other parts of the assembly.

The tests shall be performed with the upper and lower value limits of the supply voltage defined in 6.9 of IEC 62271-1:2017.

8.3.3 Verification of protection against electrical shock

Subclause 8.3.3 of IEC 62271-1:2017 is applicable.

8.3.4 Dielectric tests

Subclause 8.3.4 of IEC 62271-1:2017 is applicable.

8.4 Measurement of the resistance of the main circuit

Subclause 8.4 of IEC 62271-1:2017 is applicable with the following addition:

Where there is no continuous current test for the configuration being tested, the conditions of the test and the limits of resistance values shall be given by the manufacturer.

8.5 Tightness test

Subclause 8.5 of IEC 62271-1:2017 is applicable with the following modification:

Tightness tests shall be performed after the pressure withstand tests according to 8.103, if any.

8.6 Design and visual checks

Subclause 8.6 of IEC 62271-1:2017 is applicable.

8.101 Partial discharge measurement

This test is optional. If such a routine test is performed on the assembly, the procedure shall be in accordance with Annex B.

NOTE The measurement of partial discharges, as a routine test, can be helpful to detect possible material and manufacturing defects especially for organic solid insulating components. The test can also serve as a quality manufacturing test of assembly.

8.102 Mechanical operation tests

Operation tests shall be made to ensure that the switching devices, removable parts and auxiliary circuits function correctly and that the mechanical interlocks work properly.

The tests shall be performed as specified in 7.102 except that:

– in case of manual operation, 5 operations or attempts shall be performed in each direction with normal operating forces;
– in case of auxiliary supply voltage, and switching devices not tested within the functional unit, 5 operations or attempts shall be performed in each direction, both for the specified upper and lower limit of the auxiliary supply voltage of the operating devices;
– devices having a predetermined sequence of operation, shall be operated:
  - with the most unfavourable limit values of auxiliary supply voltage;
  - 5 times in succession in the intended conditions of use and operation;

It shall be verified that:

– the switching devices open and close correctly within the specified limits of the supply voltage and pressure of their operating devices;
– each removable part can be inserted and removed correctly;
– the interchangeability of removable components of the same rating and construction is checked (refer to 6.101);
– all interlocks function correctly;
– all auxiliary devices have operated properly;
– the effort to operate is practically the same before and after the tests.

8.103 Pressure tests of gas-filled compartments

~~Each gas-filled compartment with a filling pressure greater than 50 kPa (relative pressure) and a design pressure lower than or equal to 300 kPa (relative pressure), shall be subjected to a test at 1,3 times the design pressure for 1 min.~~

~~This is not applicable for sealed compartments with a filling pressure of 50 kPa (relative pressure) and below.~~

~~After this test the compartments shall show no signs of distress or any distortion likely to affect the operation of the assembly.~~

~~Gas-filled compartments with design pressures higher than 300 kPa (relative pressure) shall be tested according to the requirements of IEC 62271-203.~~

Each gas-filled compartment with a filling pressure above 150 kPa (absolute pressure) shall withstand during 1 min:

– 2,0 times the design pressure for cast resin, ceramic or cast aluminium gas-filled compartments without pressure relief device;
– 1,3 times the design pressure in other cases.

After this test the compartment shall show no signs of distress or any distortion likely to affect the operation of the assembly.

8.104 Tests after erection on site

After erection, the assembly shall be tested to check correct operation.

All routine tests of Clause 8 which have not been performed at the manufacturer's premises shall be performed on site.

Additionally, for parts which are assembled on site and for compartments which are gas or liquid filled on site and which all have been previously routine tested, the following is applicable:

a) Voltage test of the main circuit;

   Power-frequency voltage tests in dry conditions should be carried out on the main circuits of an assembly after the erection on site in exactly the same manner as specified in 8.2 for the routine test at the manufacturer's premises.

   The power-frequency test voltage should be 80 % of the values indicated in 8.2 and be applied to each phase conductor of the main circuit in succession with the other phase conductors earthed. For the tests, one terminal of the test transformer is connected to earth and to the enclosure of the assembly.

   Voltage transformers should be disconnected during dielectric site tests, unless the test frequency used for the site test is high enough to prevent core saturation;

b) Tightness tests: 8.5 is applicable;

c) Measurement of fluid condition after filling on site: 8.105 is applicable.

8.105 Measurement of fluid condition after filling on site

The condition of the fluid in fluid-filled compartments shall be determined and shall meet the manufacturer's specification.

9 Guide to the selection of switchgear and controlgear (informative)

9.1 General

Subclause 9.1 of IEC 62271-1:2017 is applicable with the following additions:

Assemblies may be constructed in various forms that have evolved with changing technologies and functional requirements. The selection of an assembly essentially involves an identification of the functional requirements for the service installation and the form of internal partitioning that best meets these requirements.

Such requirements should take account of applicable legislation and user safety rules.

Table 4 provides a summary of the considerations for specifying an assembly.

9.2 Selection of rated values

Subclause 9.2 of IEC 62271-1:2017 is applicable with the following additions:

For a given duty in service, the assembly is selected by considering the individual rated values of their components required by normal load and fault conditions. The rated values of an assembly may differ from those of its component parts.

The rated values should be chosen in accordance with this document having regard for the characteristics of the system as well as its anticipated future development. The list of ratings is given in Clause 5.

Other parameters such as local atmospheric and climatic conditions and the use at altitudes exceeding 1 000 m should also be considered.

The duty imposed by fault conditions should be determined by calculating the fault currents at the place where the assembly is to be located in the system. Reference is made to IEC 60909-0 in this regard [12].

9.3 Cable-interface considerations

Subclause 9.3 of IEC 62271-1:2017 is applicable with the following additions:

Users should select the type of terminations from a list provided by the manufacturer of the assembly.

Users should specify values of rated cable test voltages allowing adequate margins above the actual cable test voltages expected to be applied.

9.4 Continuous or temporary overload due to changed service conditions

Subclause 9.4 of IEC 62271-1:2017 is applicable.

9.5 Environmental aspects

Subclause 9.5 of IEC 62271-1:2017 is applicable.

9.101 Selection of design and construction

9.101.1 General

An assembly is generally identified by insulating technology (e.g. air- or gas-insulated) and by fixed or withdrawable design. The extent to which individual components should be withdrawable, or removable, is primarily dependent upon the requirement (if any) for maintenance and/or the provisions for testing. The operating instructions defined by the manufacturer should be considered for normal use, for example for the opening of the door of a procedure-based or interlock-based accessible connection compartment.

Development of switching devices with low maintenance requirement has reduced the need for frequent attention to some items subject to arc erosion. However, there remains a need for accessibility to expendable items, for example fuses, and for occasional inspection and testing of cables. Lubrication and adjustment of some mechanical parts can also be required for some designs.

The extent to which access may be required for maintenance, and/or whether complete assembly shutdowns may be tolerated, may determine a user preference for air or fluid insulation and fixed or withdrawable pattern. If maintenance demands are infrequent, as is often preferred practice nowadays, then assemblies equipped with low-maintenance components,

may provide a practical solution. Fixed pattern assemblies, particularly those employing low-maintenance components, may provide a cost-effective through-life arrangement.

9.101.2 Architecture and accessibility to high-voltage compartments

The forms of internal partitioning defined in this document attempt to balance ~~such~~ requirements as service continuity and maintainability. In this subclause, some guidance is given regarding the extent to which the different forms can provide maintainability.

NOTE 1 Temporary inserted partitions, to prevent accidental contact with live parts while performing certain maintenance procedures, are addressed in 11.5.

NOTE 2 Possible alternative maintenance procedures, e.g. the establishment of safety distances and/or setting up and use of temporary barriers, are outside the scope of this document.

The complete description of an assembly includes the list and type of high-voltage compartments, e.g. busbar compartment, circuit-breaker compartment, etc., the type of accessibility provided to each~~,~~ and the pattern (withdrawable/non-withdrawable).

There are four types of high-voltage compartments, three being accessible to the user and one non-accessible.

For accessible high-voltage compartments~~:~~ there are three methods of controlling the opening of ~~accessible high-voltage~~ these compartments ~~are defined~~:

– the first is by use of interlocks to ensure that all live parts inside are isolated and earthed before opening~~,~~ or are in the disconnected position with corresponding shutters closed. Such compartments are designated "interlock-controlled accessible compartments";

  NOTE 3 Generally, it can be possible to open shutters or temporary inserted partitions manually after accessing the high-voltage compartment.

– the second relies on user procedure and locking to ensure safety, the compartment being supplied with facilities for padlocking or equivalent; this type of compartment is designated a "procedure-based accessible compartment";

– the third does not provide any built-in feature to ensure electrical safety before opening. Such compartments need tools to be opened; they are designated "tool-based accessible compartments".

~~The first two types of accessible high-voltage compartment are available to the user and are provided for normal operation and maintenance. Corresponding covers and/or doors of these two types of accessible high-voltage compartments do not require tools for opening.~~

The first two types of accessible high-voltage compartment are available to the user to be opened for normal use (see 3.1.107). The opening of these two types of accessible high-voltage compartments can additionally require manipulating some fixing elements for opening. These compartments can also have other covers and/or doors requiring tools for opening following a proper procedure and identified with specific warning labels about the electrical risk behind if opened or removed.

If the access to a high-voltage compartment ~~requires~~ is only limited by the need of tools for opening, then this is a clear indication that this compartment is not designed for opening in normal use. The user should take other measures to ensure safety, and possibly to ensure performance integrity, e.g. insulating conditions. When made accessible, attention should be paid to the requirement (if any) to operate the switching devices without voltage/current on the main circuit with doors and covers open as part of the maintenance procedures. When made accessible, attention should be paid to the requirement (if any) to operate the switching devices without voltage/current on the main circuit with doors and covers open as part of the maintenance procedures.

Non-accessible high-voltage compartments (see 3.5.113) should not be opened by the user as the opening could destroy the integrity of the compartment. Sometimes, a ~~clear~~ indication not to open is provided on, or is evident by a feature of the compartment, e.g. a completely welded GIS tank. However, by default, every high-voltage compartment not declared accessible by the manufacturer in the manufacturer's instructions reference, is considered as a non-accessible compartment.

9.101.3 Service continuity of the switchgear

The metal-enclosure is intended to provide a level of protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects. With appropriate sensing and auxiliary control devices, it is also possible to provide a level of protection against failure of insulation.

For each functional unit of an assembly, the Loss of Service Continuity category (LSC) describes the extent to which other high-voltage compartments and/or functional units may remain energised when the connection compartment or any other high-voltage compartment of this functional unit accessible in normal use is opened. See 3.5.110 and 3.5.111.

Category LSC1: ~~this form is not intended to provide service continuity during opening of any accessible compartment(s) and may require Complete disconnection of the assembly from the system and making high-voltage conductive parts isolated and earthed before such opening.~~ this form is not intended to provide service continuity when opening any accessible compartment of the functional unit for normal use. Complete disconnection of the functional unit from the system and the isolation and earthing of the high-voltage conductive parts is required before opening any compartment.

Category LSC2 family: these forms are intended to allow maximum continuity of service of the network during access to the high-voltage compartments ~~inside~~ of the ~~assembly~~ functional unit accessible in normal use. It means that opening of accessible high-voltage compartments ~~in~~ of a functional unit in normal use is possible while keeping the other functional units of the same section energised. This implies that at least one busbar may be kept energised. Insertion of a movable partition may be used to achieve this category, refer to 11.5.

LSC2 requires as a minimum that it is possible to open the connection compartment of the functional unit while keeping the busbar(s) live. There may or may not be other ~~accessible~~ high-voltage compartments that are accessible in normal use (e.g. main switching device compartment).

LSC2A is applicable to ~~an assembly~~ a functional unit that has ~~accessible~~ compartments (at least one), other than ~~for~~ the high-voltage connection compartment, that are accessible in normal use (for instance the main switching device compartment); this requires that it is allowed, after ~~making~~ isolating and earthing the relevant high-voltage circuit ~~isolated and earthed~~, or ~~moved~~ moving the withdrawable part to the disconnected position with corresponding shutters closed, to open ~~any~~ such high-voltage compartment while keeping the busbar(s) energised (it is of course not allowed to open the live busbar compartment(s) unless the live conductors are embedded by solid insulation material and comply with at least protection category PA of IEC 62271-201:2014).

It could be of additional value to keep the high-voltage connection (e.g. cables) energized when accessing such other compartments of the corresponding functional unit. This situation can occur when alternative power supplies are part of the installation (loop operation, generators, etc.). For these situations assemblies may be specified to be LSC2B; this requires that the connection (cable) compartment may be kept energized when any other accessible high-voltage compartment is open.

The three categories of the LSC2 family can be summarized as follows:

– LSC2: Designation for functional units with accessible high-voltage connection compartments where opening the connection compartment does not require the busbar(s) nor the other functional units to be put out of service;

– LSC2A: Designation dedicated to LSC2 functional units in which all accessible high-voltage compartments (other than the busbar of single busbar equipment) may be opened with a busbar live;

– LSC2B: In addition to the requirements of LSC2A, the high-voltage connections (e.g. cables) to the functional unit being accessed may be kept energized. This implies that there also is a point of disconnection, as well as proper partitioning, between the accessed compartment and the high-voltage connections.

Examples:

1) LSC1 (Figure 1): a circuit-breaker functional unit with cable connections in the same compartment as the circuit-breaker and busbar will be categorized as LSC1.

2) LSC2 (Figure 2): a non-withdrawable circuit-breaker functional unit has two accessible high-voltage compartments (other than the busbar compartment), and a disconnector in the circuit-breaker compartment. It is not allowed to open the circuit-breaker compartment with the busbar live. However, the high-voltage connection may be earthed via the circuit-breaker: if there is full partitioning between the connection compartment and the circuit-breaker compartment, then the connection compartment may be opened with the busbar live. The functional unit should be categorized as LSC2.

3) LSC2 (Figure 3): a circuit-breaker functional unit with cable connections in the same compartment as the circuit-breaker, this compartment being accessible with the busbar live because it can be isolated and earthed by disconnector and earthing switch placed in the busbar compartment.

4) LSC2 (Figure 4): Similar to Figure 3, a typical ring main unit design (RMU) where the busbar compartment contains the switch-disconnectors or circuit breakers of several functional units is also categorized as LSC2.

5) LSC2A (Figure 5): this is similar to example 2, except that the disconnector is located in the busbar compartment, and there is full partitioning between the busbar and circuit-breaker compartments. Both the circuit-breaker compartment and the connection compartment may be opened safely with the busbar live after the disconnector is opened and the earthing switch is closed. Access to the circuit-breaker compartment requires that the cables are isolated and earthed.

6) LSC2B (Figure 6): for non-withdrawable main switching device designs. This is similar to example 4, but in addition a second disconnector and earthing switch are provided in the connection compartment; there is full partitioning between the circuit-breaker compartment and connection compartment. This allows the circuit-breaker compartment to be opened with both the busbars and connection compartment live.

7) LSC2B (Figure 7): for withdrawable designs not incorporating an integrated earthing switch on the withdrawable part. If the main switching device of each LSC2B functional unit is fitted in its own accessible compartment, maintenance may be performed on this main switching device without de-energizing the corresponding connection compartment. As a consequence, a minimum of three compartments for each LSC2B functional unit is necessary in this example:

   – for each main switching device;

   – for components connected to one side of a main switching device, e.g. feeder circuit;

   – for components connected to the other side of the main switching device, e.g. busbar.

8) ~~LSC1(Figure 8): a bus-sectionalizer functional unit with a tool-based accessible compartment and both busbar sections in one compartment is categorized as LSC1.~~

   No LSC assigned (Figure 8): a bus-sectionaliser functional unit with a tool-based accessible compartment and both busbar sections in one compartment. No LSC can be assigned, because no connection compartment is present in this functional unit. Furthermore, the only accessible compartment is a tool-based one, therefore not accessible in normal use (see 3.5.112) as defined in 3.6.101.

9) No LSC assigned (Figure 9): Sectionalizer functional unit, each busbar section is in a separate compartment. No LSC can be assigned, because no connection compartment is present in this functional unit.

In Figure 1 to Figure 9, the letter A means "Accessible compartment".

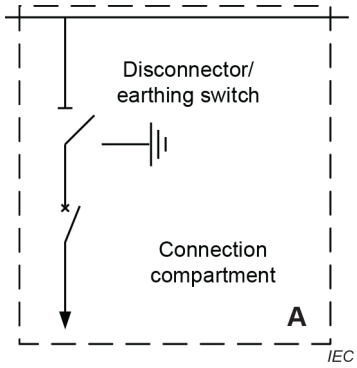


Figure 1 – LSC1

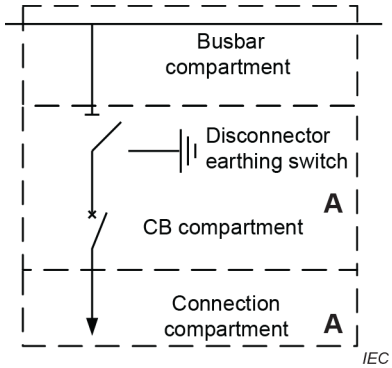


Figure 2 – LSC2

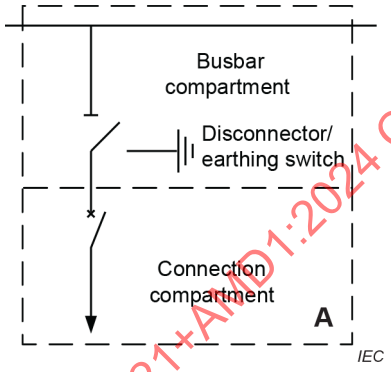


Figure 3 – LSC2

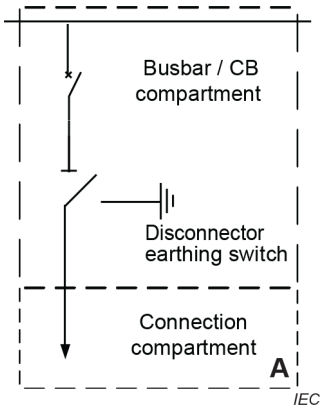


Figure 4 – LSC2

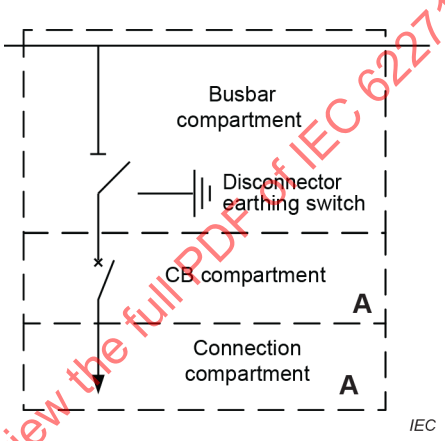


Figure 5 – LSC2A

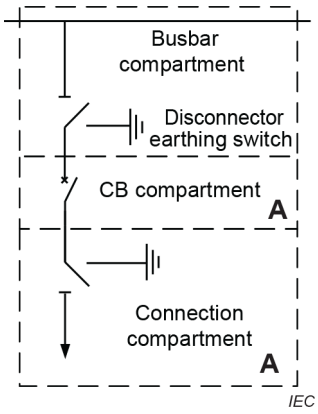


Figure 6 – LSC2B

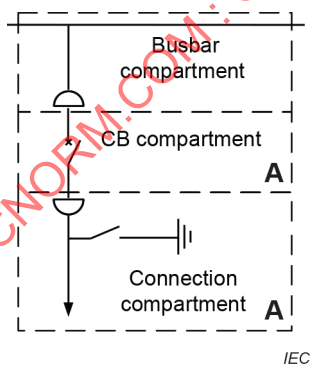


Figure 7 – LSC2B

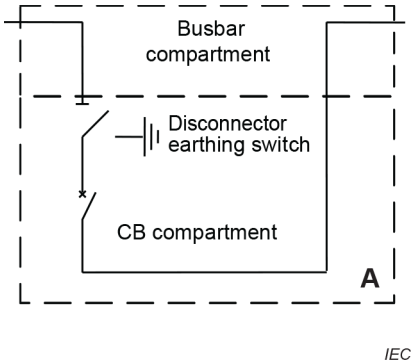


Figure 8 – ~~LSC1~~ No LSC assigned

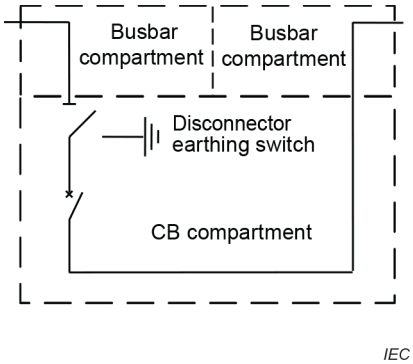


Figure 9 – No LSC assigned

9.101.4 Partition classes

There are two types of defined partition class, Class PM (3.6.107) and Class PI (3.6.108).

Class PI: one or more accessible high-voltage compartments are surrounded by at least one partition and/or shutter made from solid-insulation material. Safety aspects are covered by tests, refer to 6.103.3.3.

Class PM: accessible high-voltage compartments are surrounded only by metal partitions and/or shutters that are earthed. A shutter may or may not be visible in the opened accessible compartment itself.

The purpose is that no electric field is present in the opened compartment.

NOTE When a shutter is changing its position, the electrical field distribution around live parts behind the shutter changes. This applies especially for class PM.

9.102 Ratings related to earthing circuits

For systems with a solidly earthed neutral, the maximum phase-to-earth current of the earthing circuit I_{ke} could reach levels up to the rated short-time withstand current of the main circuit.

For systems with other than solidly earthed neutral, the maximum phase-to-earth current of the earthing circuit I_{ke} could theoretically reach levels up to 87 % of the rated short-time withstand current of the main circuit (short-circuit under conditions of double-earth fault). However, double-earth faults at independent locations have a very low probability of occurring completely through the earthing circuit of the assembly. Therefore, this condition could be not applicable and the user can select a reduced phase-to-earth short-time withstand current.

9.103 Internal arc fault

9.103.1 General

If the assembly is installed, operated and maintained in accordance with the manufacturer's instructions reference, there should be little probability that an internal arc occurs, but it may not be completely disregarded. Failure within the enclosure of an assembly due either to a defect or an exceptional service condition or maloperation may initiate an internal arc, which constitutes a hazard, if persons are present.

When selecting an assembly, the possibility of the occurrence of internal arc faults should be properly addressed, with the aim of providing an acceptable protection level for operators and, where applicable, for the general public.

This protection is achieved by reducing the risk to a tolerable level. According to ISO/IEC Guide 51:2014 [13], risk is the combination of the probability of occurrence of a harm and the severity of the harm. (Refer to Clause 5 of ISO/IEC Guide 51 2014 [13] on the concept of safety.)

Therefore, the selection of adequate equipment, in relation to internal arc, should be governed by a procedure to achieve a level of tolerable risk. Such a procedure is described in Clause 6 of ISO/IEC Guide 51:2014 [13]. This procedure is based on the assumption that the user has a role to play in the risk reduction.

9.103.2 Causes and preventive measures

Experience has shown that faults are more likely to occur in some locations inside an enclosure than in others. For guidance, Table 2 gives a list of locations where experience shows that faults are most likely to occur. It also gives causes of failure and possible measures to decrease the probability of internal arc faults. If necessary, the user should implement those applicable to the installation, commissioning, operation and maintenance.

NOTE It is well documented that the arc energy transferred during internal arc testing is not predictable by I^2t.

9.103.3 Supplementary protective measures

The first protective measure if the risk of an internal arc fault is not negligible is to specify IAC classified assemblies.

Other measures may be adopted to provide 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 current-limiting devices (e.g. fuses, or devices that employ pyrotechnic means to commutate current to a current-limiting fuse) 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;

NOTE Arc limiting devices are out of the scope of this document. For more information about arc limiting devices, refer to Cigré Technical Brochure 686 [11].

– remote operation instead of operation in front of the assembly;

– pressure-relief device;

– transfer of a withdrawable part to or from the service position only when the front door is closed.

Table 2 – Locations, causes and examples of measures to decrease the probability of internal arc faults

Locations where internal arc faults are most likely to occur (1)	Possible causes of internal arc faults (2)	Examples of possible preventive measures (3)
Connection compartments	Inadequate selection of cable and/or cable connection	Selection of adequate dimensions. Use of appropriate materials.
	Faulty installation	Avoidance of crossed cables connections. Checking of workmanship on site. Correct torque.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of liquid levels, where applicable.
Disconnectors Switches Earthing switches	Maloperation	Interlocks (refer to 6.12). Delayed reopening. Independent manual operation. Making capacity for switches and earthing switches. Instructions to personnel.
Bolted connections and contacts	Corrosion	Use of corrosion inhibiting coating and/or greases. Use of plating. Encapsulation, where possible. Supplemental heating to prevent condensation.
	Faulty assembly	Checking of workmanship by suitable means. Correct torque. Adequate locking means.
	During racking-in or racking-out of withdrawable parts, e.g. due to dielectric change of state in combination with damage or distortion of the plugging contacts and/or shutters	Checking of workmanship at site.
Instrument transformers	Ferro-resonance	Avoidance of these electrical influences by suitable design of the circuit.
	Short-circuit on low-voltage side for VTs	Avoid short-circuit by proper means, e.g. protection cover, low-voltage fuses.
Circuit-breakers	Insufficient maintenance	Regular programmed maintenance. Instructions to personnel.
All locations	Error by personnel	Limitation of access by compartmentalization. Insulation embedded live parts. Instructions to personnel.
	Ageing under electric stresses	Partial discharge routine tests.
	Pollution, moisture ingress of dust, vermin, etc.	Measures to ensure that the specified service conditions are achieved (refer to Clause 4). Use of gas-filled compartments.
	Overvoltages	Surge protection. Adequate insulation co-ordination. Dielectric tests on site.

9.103.4 Considerations for the selection and installation

The user shall make a proper selection, taking into account the characteristics of the network, operating procedures and service conditions. As well, considering the protection of the persons during service, the following points shall be considered:

– not all assemblies are IAC classified;

– not all assemblies are of withdrawable design;

– not all assemblies are fitted with a door which can be closed in the positions defined in 3.6.109 to 3.6.110.

As a guide for the selection of the adequate assembly with respect to the risk of internal arcs, the following criteria may be used:

– where the risk is considered negligible, IAC classification is not necessary for the assembly;
– where the risk is considered to be relevant, only assemblies with IAC classification should be used.

For the second case, the selection should be made by taking into account the foreseeable maximum level of current and duration of the fault, in comparison with the rated values of the tested equipment. In addition, the installation instructions of the manufacturer should be followed (refer to Clause 11). In particular, the location of personnel during an internal arc event is important. The manufacturer should indicate which sides of the assembly are classified as accessible and the user should follow the instruction carefully. Allowing personnel to enter an area not designated as accessible may lead to personnel injury.

The protection of persons in case of an internal arc is not only a matter of design and IAC classification of the assembly, but depends also on the installation conditions. Internal arc faults inside an assembly can occur in a number of locations and can cause various physical phenomena. For example, the arc energy resulting from an arc developed in any insulating fluid within the enclosure will cause an internal overpressure and local overheating which will result in mechanical and thermal stressing of the equipment. Moreover, the materials involved may produce hot decomposition products, either gaseous or vaporous, which may be discharged to the outside of the enclosure. From this point of view, immediate evacuation and further ventilation of the switchgear room, before re-entering the site, is required and appropriate measures should be considered for the installation on site.

9.103.5 Internal arc test

The internal arc test is in general intended to verify the effectiveness of the design in protecting persons in case of an internal arc, when the assembly is in normal operating condition. This test does not assess the behaviour of the assembly under any condition of maintenance or work, when parts of the enclosure, including the low-voltage compartment, are open or dismantled.

The internal arc test is only applicable to assemblies that have an assigned internal arc classification.

Internal arc tests are not intended to cover for example:

– the influences of an internal arc between compartments, nor the damage to internal partition and shutters not being accessible in normal operating conditions;
– arc faults outside the enclosure, for example in the connecting cables;
– the effects caused by an explosion of high-voltage components;
– the presence of gases with potential toxic characteristics, or the hazard of fire propagation to combustible materials or equipment placed in the proximity of the assembly;
– the effect of change of state of shutters while withdrawable or removable parts are moving;
– arc faults during operation of switching devices or during connection or disconnection of removable components;
– arc faults during maintenance works;
– overpressure effects inside the building where the hot gases are released.

NOTE 1 IEEE C37.20.7 addresses IAC classification with Suffix B designation for opened low-voltage compartments and with Suffix C designation for arc protection between compartments [5].

NOTE 2 It is in general not possible to calculate the permissible arc duration for a current which differs from that used in the test. The maximum pressure during the test will generally not decrease with a shorter arcing time and there is no universal rule according to which the permissible arc duration can be increased with a lower test current.

NOTE 3 Lower current level can influence the behaviour of the pressure relief devices and the burn through performance.

9.103.6 IAC classification

9.103.6.1 General

Classification IAC gives a tested level of protection of persons under conditions as stated in 7.105.2. It relates to personnel protection under these conditions; it does not relate to personnel protection under maintenance conditions nor to service continuity.

In the case where classification IAC is assigned according to 5.103, the assembly will be designated as follows:

– general: classification IAC (initials for Internal Arc Classification);
– accessibility: A or B (according to 5.103.2 and A.2.2);
– classified sides: F,L, R (according to 5.103.2 and A.2.2);
– rated values: arc fault current in kilo-amperes (kA), and duration in seconds (s). Single-phase values may be assigned to an assembly, having one or more compartments where its construction will prevent the arc from becoming multiphase, as demonstrated during the internal arc test. The relationship between network neutral earthing and single-phase-to-earth arc fault current is given in Table 3. Users should specify a single-phase-to-earth arc fault current rating when they require a value higher than 87 % of the three-phase rating, or may accept a lower value, depending on the network neutral earthing.

Table 3 – Single-phase-to-earth arc fault current depending on the network neutral earthing

Type of network neutral earthing	Single-phase-to-earth arc fault current
Isolated neutral	up to 87 % of the three-phase rated arc fault current
Impedance earthed neutral	100 % of the rated single-phase-to-earth arc fault current
Solidly earthed neutral	100 % of the three-phase rated arc fault current
NOTE 1 If the rated single-phase-to-earth arc fault current covers the condition of solidly earthed neutral, all other earthing conditions of the network are also covered. NOTE 2 For systems with isolated neutral, the maximum single-phase-to-earth fault current could theoretically reach levels up to 87 % of the three-phase rated arc fault current (single-phase-to-earth fault current under conditions of double-earth fault). However, double-earth faults at independent locations in the proximate vicinity of a single-phase-to-earth fault subjected assembly have a very low probability. Therefore, this condition is sometimes not applicable and the user can specify a reduced single-phase-to-earth arc fault current rating.	

The designation is included in the product documentation (refer to 6.11).

9.103.6.2 Examples

EXAMPLE 1

An assembly rated for a fault current (RMS) of 12,5 kA, for 0,5 s and for installation in a site of public accessibility in front, lateral and rear side, is designated as follows:

IAC	BFLR
Arc fault current	12,5 kA
Arc fault duration	0,5 s

Designation: IAC BFLR 12,5 kA, 0,5 s

EXAMPLE 2

An assembly rated for a fault current (RMS) of 16 kA, for 1 s and for installation in the following conditions:

front:	public accessibility
rear:	restricted to operators
lateral:	not accessible

is designated as follows:

IAC	BF-AR
Arc fault current	16 kA
Arc fault duration	1 s

Designation: IAC BF-AR 16 kA, 1 s

EXAMPLE 3

An assembly, restricted to be used with plug-in connectors in earth fault protected, isolated neutral or impedance earthed networks where a maximum earth fault current of 2 kA prevails. If rated for a fault current (RMS) of 20 kA, for 0,5 s, but for the connection compartment only for 2 kA for 1 s, with assigned access, for authorized personnel only, to front, lateral and rear side, is designated as follows:

IAC	AFLR
Arc fault current	20 kA
Arc fault duration	0,5 s
Single-phase-to-earth arc fault current	2 kA
Single-phase-to-earth arc fault duration	1 s

Designation: IAC AFLR 20 kA, 0,5 s (connection compartment I_{Ae}: 2 kA, 1 s)

EXAMPLE 4

An assembly with solid-insulation enclosing the high-voltage conductors, rated for a single-phase fault current (RMS) of 12,5 kA, for 0,5 s and for installation in a site of public accessibility in front, lateral and rear side, is designated as follows:

IAC	BFLR
Single-phase-to-earth arc fault current	12,5 kA
Single-phase-to-earth arc fault duration	0,5 s

Designation: IAC BFLR I_{Ae}: 12,5 kA, 0,5 s

EXAMPLE 5

An assembly with a top compartment for the voltage transformers, protected by fuses that are located in another compartment.

The functional unit is tested for a fault current of 20 kA for 1s except the voltage transformers compartment which is tested with the (dummy) fuse type that causes the highest cut-off current (refer to 7.105.2).

The assembly intended to be installed in rooms for authorized personnel only with access to front and lateral sides, is designated as follows:

IAC	AFL
Arc fault current	20 kA
Arc fault duration	1 s

Designation: IAC AFL 20 kA, 1 s (VT-compartment: fuse protected)

EXAMPLE 6

An assembly with arc limiting devices being integral part of the design without the possibility to make them inoperative, as declared by the manufacturer, are tested with the 16 kA short-circuit current and a protection relay setting of 1 s. The duration of the arc is defined by the characteristics of the arc limiting device at 45 ms (refer to 7.105.2).

The assembly intended to be installed in rooms for authorized personnel only with access to the front, lateral and rear sides is designated as follows:

IAC	AFLR
Arc fault current	16 kA
Arc fault duration	0,045 s

Designation: IAC AFLR 16 kA, 0,045 s

9.104 Summary of technical requirements, ratings and optional tests

Technical requirements, ratings and optional tests for assemblies are summarized in Table 4.

Table 4 – Summary of technical requirements, ratings and optional tests for assemblies

Information	Clause/subclause of this document	User to indicate requirement as appropriate (leave blank if unknown or not relevant)
Particulars of system (not equipment rating):		
Nominal voltage kV		
Frequency Hz		
Number of phases		
Type of network neutral earthing	9.102	
Characteristics of the assembly		
Number of poles		
Class – indoor, outdoor (or special service conditions)	4	

Information	Clause/subclause of this document	User to indicate requirement as appropriate (leave blank if unknown or not relevant)
Type of compartment (specify type for each high-voltage compartment) if applicable: Interlock-controlled accessible compartment Procedure-based accessible compartment Tool-based accessible compartment Non-accessible compartment	3.5.109 3.5.110 3.5.111 3.5.112 3.5.113	Busbar compartment: Main device compartment: Connection compartment: CT compartment: VT compartment: Connection/CT compartment: Main switching device/CT compartment: Other compartments (state):
Partition class Class PM Class PI	3.6.106 3.6.107 3.6.108	
Withdrawable/non-withdrawable (main device type)	3.5.120	(Withdrawable/non-withdrawable):
Loss of service continuity category (LSC) per type of functional unit LSC2 LSC2A LSC2B LSC1	 3.6.102 3.6.103 3.6.104 3.6.105	
Rated voltage U_r 3,6 kV; 7,2 kV; 12 kV; 17,5 kV; 24 kV; 36 kV, etc.	5.2	
Number of phases 1, 2 or 3		
Rated insulation level: power-frequency withstand voltage U_d Lightning impulse withstand voltage U_p	5.3	(Common value/across the isolating distance) a) / b) /
Rated frequency f_r	5.4	
Rated continuous current I_r Incomer Busbar Feeder	5.5	 a) b) c)
Rated short-time withstand current Main circuit (incomer/busbar/feeder) I_k Phase-to-earth earthing circuit I_{ke}	5.6 9.102	 a) b)
Rated peak withstand current Main circuit (incomer/busbar/feeder) I_p Phase-to-earth earthing circuit I_{pe}	5.7 9.102	 a) b)
Rated duration of short-circuit Main circuit (incomer/busbar/feeder) t_k, Phase-to-earth earthing circuit t_{ke}	5.8 9.102	 a) b)

Information	Clause/subclause of this document	User to indicate requirement as appropriate (leave blank if unknown or not relevant)
Rated supply voltage of closing and opening devices and of auxiliary and control circuits U_a a) Closing and tripping b) Indication c) Control	5.9	 a) b) c)
Rated supply frequency of closing and opening and of auxiliary circuits	5.10	
Internal arc fault IAC Types of accessibility to the assembly (specify the side(s) for which they are required) A restricted to authorized personnel only B unrestricted accessibility (includes public) Classification current value in kA and duration in s	3.6.106 5.103.2 Examples in 9.103.6 5.103.4 and 5.103.5	Y/N F for front side: L for lateral side: R for rear side:
Rated cable test voltages U_{ct}	5.102	AC and/or DC
Low- and high-pressure interlocking and monitoring devices (state requirements e.g. lock-out on low-pressure indication, etc.)	6.10	
Locking devices (state any additional requirements to 5.11)	6.12	
Degrees of protection by enclosures (if not IP2X): With doors closed With doors open Weatherproofing test	6.14.2 (refer to 6.102.1 and 6.102.3) 6.14.3	 a) b)
Partial discharge tests	7.2.10	Agree with manufacturer the test values
Partial discharge measurement	8.101	Agree with manufacturer the test values
Additional information, e.g. installation conditions		

10 Information to be given with enquiries, tenders and orders (informative)

10.1 General

Subclause 10.1 of IEC 62271-1:2017 is applicable.

10.2 Information with enquiries and orders

Subclause 10.2 of IEC 62271-1:2017 is not applicable.

When enquiring about or ordering an assembly, the following information should be supplied by the enquirer.

a) Particulars of the system:

Nominal and highest voltage, frequency, type of system network neutral earthing.

b) Service conditions if different from normal service conditions (refer to Clause 4):

To be addressed is any condition deviating from the normal service conditions, as, for example, exposure to unusual vapour, moisture, fumes, explosive gases, excessive dust or salt, thermal radiation (e.g. solar), altitude, the risk of earth tremors or other vibrations due to causes external to the equipment to be delivered.

c) Specification of the assembly:

1) indoor or outdoor installation;
2) number of phases;
3) number of busbars, as shown in the single line diagram;
4) rated voltage;
5) rated frequency;
6) rated insulation level;
7) rated continuous currents of busbars and feeder circuits;
8) rated short-time withstand current (I_k);
9) rated duration of short-circuit (if different from 1 s);
10) rated peak withstand current (if different from 2,5 I_k);
11) rated cable test voltages, if required;
12) rated values of components;
13) degree of protection for the enclosure and partitions;
14) circuit diagrams;
15) description by name and type (accessibility) of the various compartments, if required;
16) loss of service continuity category (LSC1, LSC2, LSC2A or LSC2B) for each type of functional unit, where applicable;
17) Partition class (PM or PI), if any;
18) classification IAC, if required, with corresponding accessibility type, arc fault current and duration, as applicable.

d) Particulars of the operating devices:

1) type of operating devices;
2) rated supply voltage (if any);
3) rated supply frequency (if any);
4) rated supply pressure (if any);
5) special interlocking requirements.

Beyond these items, the enquirer should indicate every condition which might influence the tender or the order, for example, special mounting or erection conditions, the rules for pressure vessels, requirements for cable testing, treatment of exhausting gases, specific dimensions.

The enquirer should state any request for conformity assessment information, documentation or procedure. Information should be supplied if special type tests and/or routine tests are required.

10.3 Information with tenders

Subclause 10.3 of IEC 62271-1:2017 is not applicable.

The following information, if applicable, should be given by the manufacturer with descriptive material and drawings:

a) Rated values and characteristics as enumerated in item c) of 10.2;

b) Conformity assessment evidence as requested;

c) Constructional features, for example:

1) mass of the heaviest transport unit;
2) overall dimensions of the installation;
3) arrangement of the connections to external conductors;
4) facilities for transport and mounting;
5) mounting provisions;
6) description by name and category of the various compartments;
7) classified sides;
8) instructions for installation, operation and maintenance;
9) type of gas-pressure or liquid-pressure system;
10) filling level and minimum functional level;
11) volume of liquid or mass of gas or liquid for the different compartments;
12) specification of gas or liquid condition.

d) Particulars of the operating devices:

1) types and rated values as enumerated in item d) of 10.2;
2) current or power for operation;
3) operating times;
4) list of recommended spare parts that should be procured by the user.

11 Transport, storage, installation, operating instructions and maintenance

11.1 General

Subclause 11.1 of IEC 62271-1:2017 is applicable.

11.2 Conditions during transport, storage and installation

Subclause 11.2 of IEC 62271-1:2017 is applicable.

11.3 Installation

Subclause 11.3 of IEC 62271-1:2017 is applicable with the following additions to 11.3.4:

The purchaser (user) should evaluate the risks of the installation and decide how to install the assembly. However, it should be noted that in the case of IAC classified assemblies, any deviation from the installation instructions, which shall be provided by the manufacturer, could impair the internal arc performance.

Possible overpressure inside the building, due to an internal arc fault in the assembly, should be considered.

11.4 Operating instructions

Subclause 11.4 of IEC 62271-1:2017 is applicable with the following additions:

The individual high-voltage compartments of each type of functional unit shall be defined from the four types of high-voltage compartments that are distinguished; three that can be opened, called accessible and one not designed to be opened, called non-accessible, refer to 3.5.110 to 3.5.113.

The manufacturer shall state in the manufacturer's instructions reference which type is applicable for each compartment within the assembly.

– For interlock-controlled accessible compartments, refer to 6.12 and 6.102.2;
– For procedure-based or tool-based accessible compartments, refer to 6.102.2;
– Special procedures are required for opening tool-based accessible compartments;
– Non-accessible compartments should not be opened by the user as the integrity of the compartment could be destroyed.

The LSC category of each type of functional unit shall be given, where applicable (refer to 3.6.101 and 6.103).

Operating instructions are provided as "Instructions for Use" which shall be defined in the manufacturer's instructions reference. This is considered as part of "normal use". Refer to 3.1.107.

11.5 Maintenance

Subclause 11.5 of IEC 62271-1:2017 is applicable with the following additions:

If temporarily inserted partitions are required, while performing certain maintenance procedures, to prevent accidental contact with live parts, then:

– the manufacturer shall offer to supply the required partitions or their design;
– the manufacturer shall give advice direction regarding the maintenance procedure and use of partitions;
– when installed according to the manufacturer's directions, the requirements IP2X (according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013) shall be met;
– such partitions shall meet the requirement of 6.103.3;
– the partitions and their supports shall have sufficient mechanical strength to avoid incidental contact of live parts.

NOTE Barriers and supports provided for mechanical protection only are not subject to this document.

After a short-circuit event in service, the earthing circuit should be examined for potential damage and replaced in whole or in part if needed.

12 Safety

Clause 12 of IEC 62271-1:2017 is applicable, with the following additions:

12.101 Procedures

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 isolated and earthed, or in the withdrawn position with corresponding shutters closed, or that parts remaining live are embedded by solid-insulation material complying with at least class PA of IEC 62271-201:2014. Procedures may be dictated by legislation of the country of installation or by user safety documentation (e.g. EN 50187 [14]).

12.102 Internal arc aspects

As far as the protection of persons is concerned, the correct performance of the assembly in case of an internal arc is not only a matter of design of the equipment itself, but also of the installation conditions and operating procedure, refer to 9.103 and 11.3.

13 Influence of the product on the environment

Clause 13 of IEC 62271-1:2017 is applicable.

Annex A
(normative)

Internal arc fault – Method to verify the internal arc classification (IAC)

A.1 Room simulation

A.1.1 Room simulation for indoor assemblies

The room shall be represented by a floor, ceiling and two walls perpendicular to each other. Where intended for evacuation of internal arc gases, simulated cable access ways and/or exhaust ducts shall also be built.

NOTE 1 The dimensions of the room simulation establish defined test conditions, however real installation conditions generally deviate, refer to 11.3.

Ceiling

The test shall be performed at a ceiling height as specified by the manufacturer.

The ceiling height is always stated from the floor or false floor level where the assembly is actually placed, refer to Figure A.8. This is also the level where the indicator racks are placed during the IAC test.

However, the ceiling shall be located as a minimum:

- at a distance not less than 200 mm (±50 mm) above the height of the test object and
- at a distance of 2 000 mm (±50 mm) from the floor or false floor, if the height of the test object is less than 1 800 mm, refer to Figure A.5.

The height of the test object is determined by its most upper part that influences the gas flow, including pressure relief flaps (if any) in the highest open position by design and construction. The pressure relief flaps shall not strike the ceiling during opening.

The test results performed with these conditions are valid for all distances between test object and ceiling larger than the tested ones.

EXAMPLE A test performed with a distance between the test object and ceiling of 600 mm is valid for this and all higher distances.

If the manufacturer states a distance between the ceiling and the height of the test object between 0 mm and 200 mm, the test results are only valid for this ceiling distance and this distance may be declared as admissible for the installation instructions.

Lateral wall

The lateral wall shall be placed at 100 mm (±30 mm) from the left or right lateral side of the test object. A lower distance may be chosen provided that it can be demonstrated that any permanent deformation of the lateral side of the test object is not interfered with or limited by the wall.

The test results performed with these conditions are valid for all distances between the test object and lateral wall larger than the tested ones, provided that the gases are not directed to the walls.

Rear wall

The test object shall be placed at a distance to the rear wall depending on the accessibility of the rear side of the assembly. Test objects consisting of functional units with various depths shall have the required distances at the functional unit with the largest depth.

In all cases the distance from the rear wall to the assembly is measured from the surface of the enclosure, disregarding protruding elements not expected to influence the evacuation of hot gases (e.g. handles).

Non-accessible rear side

Unless the manufacturer states a larger minimum clearance, the wall shall allow a clearance to the rear of the test object of 100 mm (±30 mm). A lower clearance may be chosen provided that it can be demonstrated that any permanent deformation of the rear side of the test object is not interfered with or limited by the wall.

This test arrangement is deemed valid for an installation mounted closer to the wall than the test arrangement, provided that two additional conditions are met (refer to 7.105.5 criterion No. 1).

If these conditions cannot be demonstrated, or the manufacturer requires direct qualification of a wall-mounted design, a specific test without clearance to the rear wall shall be carried out. However, the validity of such a test shall not be extended to any other installation condition.

When the test is carried out at any larger clearance to the rear wall, as stated by the manufacturer, this clearance shall be declared as a minimum admissible for the installation instructions. The instructions shall also include guidance on the obligation to adopt measures preventing persons to enter that area.

Accessible rear side

The rear wall shall leave a standard clearance of 800 mm ($^{+100}_{0}$ mm) from the rear side of the test object.

The test also covers installation conditions with the rear side at a distance to the wall of 300 mm and more in case of accessibility type A has been tested, or 100 mm and more in case of accessibility type B has been tested, although such installation conditions may prevent actual access to the rear side. A lower clearance than 300 mm to the rear wall may be covered by the type A test for accessible rear side, when the type A indicators are fitted at the rear side as for accessibility type B.

Special case, use of exhausting ducts

If the manufacturer claims that the design requires that cable access way and/or any other exhausting duct, not belonging to the assembly, need to be used to evacuate gases generated during the internal arc, their minimum cross-section dimensions, location and output features (flaps or grid, with their characteristics) shall be stated by the manufacturer. The test shall be carried out with simulation of such exhausting ducts. The output end of the exhausting ducts shall be at least 2 000 mm away from the assembly under test.

If tests are performed with the exhausting duct installed on top of the object, the recommended distance of the test object to the ceiling is 100 mm (±50 mm), in order to document in the test report permanent deformations of the exhausting duct. The test results performed with this distance are valid for all distances between test object and ceiling larger than the tested one.

If the exhausting duct is mounted below the assembly, the simulated false floor shall be placed at a height allowing installation of the specified duct, refer to Figure A.8 b).

NOTE 2 The possible effects of hot gases at the end and around the exhausting duct beyond the indicators, are not covered by the tests in this document.

A.1.2 Room simulation for outdoor assemblies

Neither ceiling nor walls are required if accessibility is stated for all sides (F, L, R). Simulation of cable access ways shall be constructed, if necessary, as indicated above.

From the point of view of internal arc, an outdoor assembly with IAC performance validated under indoor installation conditions is considered to be validated also for outdoor application with the same accessibility requirements, cable access ways and floor disposition.

In cases where assemblies for outdoor application are intended to be placed under a shelter (e.g. for protection against rain) which lowest part is less than 1 500 mm above the assembly, a corresponding ceiling shall be placed for internal arc test. If such an assembly has already been tested for indoor installation conditions, the outdoor application is already covered in this respect. The ceiling height used for the indoor test is considered as minimum height for the shelter.

A.2 Indicators (for assessing the thermal effects of the gases)

A.2.1 General

Indicators are pieces of black cotton cloth so arranged that their cut edges do not point toward the test object.

Black cretonne (cotton fabric approximately 150 g/m^2) or black cotton-interlining lawn (approximately 40 g/m^2) shall be used for indicators, depending on the accessibility condition.

NOTE Black cretonne (cotton fabric approximately 150 g/m^2) is considered to represent workman's clothes, whereas cotton-interlining lawn (approximately 40 g/m^2) is considered to represent light summer wear of the general public.

It shall be prevented that vertical indicators can ignite each other. This is achieved by fitting them in a frame of steel sheet, with a depth of 2 × 30 mm ($^{0}_{-3}$ mm) (refer to Figure A.1).

With the horizontal indicators, ensure that glowing particles do not accumulate. This is achieved if the indicators are mounted without frame (refer to Figure A.2).

The indicator dimensions shall be 150 mm × 150 mm ($^{+15}_{0}$ mm).

A.2.2 Arrangement of indicators

Indicators shall be placed at each classified side on a mounting rack, at distances depending on the type of accessibility. Both vertical and horizontal indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the areas to check.

The length of the mounting rack shall be larger than the test object to take into account the possibility of hot gases escaping at angles of up to 45°, from the surface under test. This means that the mounting frame on each side, if applicable, shall be at least 100 mm longer than the functional unit under test in case of accessibility type B, or at least 300 mm in case of accessibility type A, provided that the position of the wall in the arrangement of the room simulation does not limit this extension.

The requirements for the indicators are:

a) Accessibility type A (authorized personnel)

Black cretonne (cotton fabric approximately 150 g/m^2) shall be used for the indicators.

Indicators shall be fitted vertically at all classified sides of the assembly up to a height of 2 000 mm (±50 mm), refer to Figure A.3 and Figure A.4.

The distance from the indicators to the assembly shall be 300 mm (±15 mm).

Indicators shall also be arranged horizontally at a height of 2 000 mm (±50 mm) above the floor as described in Figure A.3 and Figure A.4 and covering the whole area between 300 mm (±30 mm) and 800 mm (±30 mm) from the assembly. When the ceiling is placed at a height of 2 000 mm (±50 mm) above the floor (refer to A.1.1) no horizontal indicators are required, refer to Figure A.3 and Figure A.5.

A special accessibility condition is where normal operation requires persons to stand or walk upon the equipment, horizontal indicators shall be placed above the upper accessible surface, as described in Figure A.7 (as example a particular case of accessibility type B), whatever the height of the assembly; black cotton-interlining lawn (approximately 40 g/m^2) shall be used for these horizontal indicators.

b) Accessibility type B (general public)

Black cotton-interlining lawn (approximately 40 g/m^2) shall be used for indicators for the type B classified sides.

The distance from the vertical indicators to the assembly shall be 100 mm (±5 mm).

– For test objects greater than or equal to 1 900 mm:

  Vertical indicators shall be fitted vertically at all classified sides for the assembly up to 2 000 mm (±50 mm) above the floor, refer to Figure A.3 and Figure A.6.

  Horizontal indicators shall be arranged at a height above the floor and covering the whole area between 100 mm (±5 mm) and 800 mm (±50 mm) from the assembly, refer to Figure A.6.

– For test objects with actual height lower than 1 900 mm:

  Vertical indicators shall be fitted up to a height 100 mm (±50 mm) higher than the test object, refer to Figure A.3 and Figure A.7.

  Horizontal indicators shall be placed above the upper accessible surface, at a distance of 100 mm (±5 mm), refer to Figure A.7.

The distance from the indicators fitted vertically to the assembly is measured from the surface of the enclosure of the functional unit under test, disregarding protruding elements not expected to influence the evacuation of hot gases (e.g. handles).

If the surface of the assembly is not regular, the indicators for accessibility type A shall be placed as shown in Figure A.9, and in case of accessibility type B, the indicators shall be placed 100 mm from the surface of the protrusion.

In the case where a bottom exhaust duct is part of the assembly and is walkable as integrated part of the simulated false floor, additional horizontal indicators shall be placed 100 mm above the bottom exhaust duct in an area between the vertical indicators and 800 mm from the assembly, refer to Figure A.10.

A.3 Tolerances for geometrical dimensions of test arrangements

Summary of tolerances for geometrical dimensions of test arrangements as given in the text (the values given there in brackets are tolerances only for the actual test arrangement and do not extend the required values):

Distance between test object and ceiling:	±50 mm
Distance between test object and lateral wall:	±30 mm
Distance between test object and rear wall (non-accessible):	±30 mm
Distance between test object and rear wall (accessible):	0/+100 mm
Indicator dimensions:	0/+15 mm
Depth of the steel frame for indicators:	–3/0 mm
Height of indicators:	±50 mm
Distance between test object and indicators	
Accessibility type A:	±30 mm
Accessibility type B:	±5 mm

A.4 Test parameters

A.4.1 General

A test performed at a given voltage, current and duration is generally valid for all lower values of current, voltage and duration.

A.4.2 Voltage

The test shall be performed at any suitable voltage up to and including the rated voltage. If a voltage lower than the rated voltage is chosen, the following conditions shall be met.

a) the average RMS current value during the test as computed by a digital recording device complies with the current requirements of A.4.3.1;

b) the arc is not extinguished prematurely in any of the phases in which it has been initiated. Temporary single-phase extinguishing is permitted, as long as the cumulated duration of the intervals without current does not exceed 2 % of the test duration and the single events last no longer than to the next prospective current zero, provided that the integral of the AC component of the current equals at least the value specified in A.4.3.1 in the relevant phase.

A.4.3 Current

A.4.3.1 AC component

The test current shall be set within a ±5 % tolerance of the rated arc fault current (I_A or I_{Ae}). If the applied voltage is equal to the rated voltage, this tolerance is applicable only to the prospective current.

The current should remain constant. If the capability of the test plant does not permit this, the test shall be extended until the integral of the AC component of the current (I*t) equals the value specified within a tolerance of ($^{+10}_{0}$ %). In this case, the current shall be equal to the specified value at least during the first three half-cycles and shall not be less than 50 % of the specified value at the end of the test.

If a value of I_{Ae} is assigned to the assembly which is greater than 87 % of I_A, any two-phase tests shall use the value of I_{Ae} for the test current.

NOTE Rationale for 87 % is the arc fault test with 2-phase ignition.

A.4.3.2 Peak current

The instant of closing shall be chosen so that the peak current is flowing in one of the outer phases, and a major loop also occurs in the other outer phase.

If the applied voltage is equal to the rated voltage, the peak value of the prospective current shall be set to 2,5 times (for frequencies up to 50 Hz) or 2,6 times (for both 50 Hz and 60 Hz) the RMS value of the AC component defined in A.4.3.1 with a tolerance of $^{+5}_{0}$ %. If a higher DC time constant is specified by the manufacturer, a uniform value of 2,7 times the RMS value of the AC component should be used as a rated value for both 50 Hz and 60 Hz applications.

If the voltage is lower than the rated voltage, the peak value of the prospective current is irrelevant, but the peak value of the test current shall not drop below 90 % of the rated peak value.

In case of two-phase initiating of the arc, the instant of closing shall be chosen to provide the maximum possible DC component.

A.4.4 Frequency

At a rated frequency of 50 Hz or 60 Hz, the frequency at the first three half-cycles of the test shall be between 48 Hz and 62 Hz. At other frequencies it shall not deviate from the rated value by more than ±10 %.

A.5 Test procedure

A.5.1 Supply circuit

A.5.1.1 Three- and two-phase tests

The supply circuit shall be three-phase and all three phases of the assembly shall be energized. The neutral point of the supply circuit may be either isolated or earthed through an impedance, in such a way that the maximum earth current is less than 100 A. In this situation, the arrangement covers all situations of neutral treatment.

A.5.1.2 Single-phase tests

One terminal of the supply circuit shall be connected to the earthing point provided on the assembly, the other to the phase under test.

The two remaining phases of the test object shall be energized at rated phase-to-earth voltage. No difference in phase angle is needed. The source(s) may be low power and are not intended to supply any significant short-circuit current in case of ignition.

If any of the remaining phases ignites, the test shall be repeated as a three-phase test.

A.5.1.3 Feeding arrangements

Feeding direction shall be as follows:

– for a connection compartment: supply from the busbar, through the main switching device;

– for a busbar compartment: the supply connections shall not introduce any opening in the compartment under test. Supply shall be made through one barrier or through a suitable feeder functional unit, from the opposite end of the assembly. In case of non-symmetrical designs of busbar compartment, the most onerous internal arc initiation should be considered, with respect to arc energy and burn through;

– for the main switching device compartment: supply from the busbar, with the device in closed position;
– for a compartment with several main circuit components inside: supply through one available set of incoming bushings, with all switching devices in closed position, except for earthing switches, if any, which shall be in open position.

A.5.2 Arc initiation

A.5.2.1 General

The arc shall be initiated between all the phases under test by means of a metal wire of about 0,5 mm in diameter or, in the case of a single-phase-to-earth arc fault current, between one phase and earth.

The point of initiation shall be located at the furthest point, downstream in the current path from the supply, within the compartment under test. If the main circuit of the compartment under test includes current limiting devices (e.g. fuses), the point of initiation shall be chosen upstream from the limiting device.

The number of phases to be tested, the connection arrangements, and the action to be taken if other phases are affected, shall be in accordance with Table A.1, according to the construction of the compartment under test.

If a value of I_{Ae} is assigned to the assembly at least one compartment shall be tested single-phase-to-earth.

In the case of single-phase-to-earth ignition, the arc shall be initiated between the middle phase and closest earth.

In the case of two-phase ignition, the arc shall be initiated between the middle phase and the outer phase, where outer phase is determined as being furthest away from the supply side and closest to the indicators on the IAC classified sides, where applicable.

A.5.2.2 Compartments with solid-insulation

In compartments where the live parts are covered by solid insulating material, the arc shall be initiated at the following locations:

a) at gaps or joining surfaces between the insulation of insulation-embedded parts;
b) by perforation at insulated joints made on site when prefabricated insulating parts are not used;
c) when a) and b) are not applicable, by perforation or partial removal of solid-insulation from the conductors.

A.5.2.3 Connection compartments

A.5.2.3.1 Compartments with plug-in solid-insulation connections

For outer-cone plug-in connections, the phase(s) to be ignited shall be fitted with lugs without insulation.

For inner cone connections, the initiation shall be made by perforating or partly removing their insulation directly below the cable plug(s) of the phase(s) to be ignited.

The other phase(s) shall be provided with a plug-in connector as may be used in service, able to be energized with at least the voltage as used for the actual test.

A.5.2.3.2 Compartments with site-made solid-insulation connections

For connection compartments in which connections are made with site-made solid-insulation connections, the phase(s) to be ignited shall be fitted with lugs without insulation.

A.5.2.3.3 Compartments without plug in or site-made solid-insulation connections

Cable connections without plug-in or site-made insulation connections shall be tested without cables. The ignition shall be made three-phase.

Cable lugs shall be fitted in their service configuration.

A.5.2.4 Single-phase compartments without any earthed metallic parts

For single-phase compartments without any earthed metallic parts, a path shall be created through the insulation to the closest earthed metallic part.

Table A.1 – Parameters for internal arc test according to compartment construction

		Test current	Number of phases/earth for arc initiation	Action if other phase affected
Three-phase compartments, other than connection compartments:	with bare conductors	I_A	Three	N/A
	conductors with site-made solid-insulation	I_A	Three	N/A
	conductors with non site-made solid-insulation	Max of (87 % I_A and I_{Ae})	Two	Repeat as three-phase test in the compartment where the affection took place
		I_{Ae}	One phase and earth	
Single-phase compartments:		I_{Ae}	One phase and earth	
Connection compartments:	connections uninsulated or fitted with site-made solid-insulation	I_A	Three	N/A
	outer or inner cone plug-in connections (screened or unscreened)	Max of (87 % I_A and I_{Ae})	Two	Repeat as three-phase test in the compartment where the affection took place
		I_{Ae}	One phase and earth	

Dimensions in millimetres

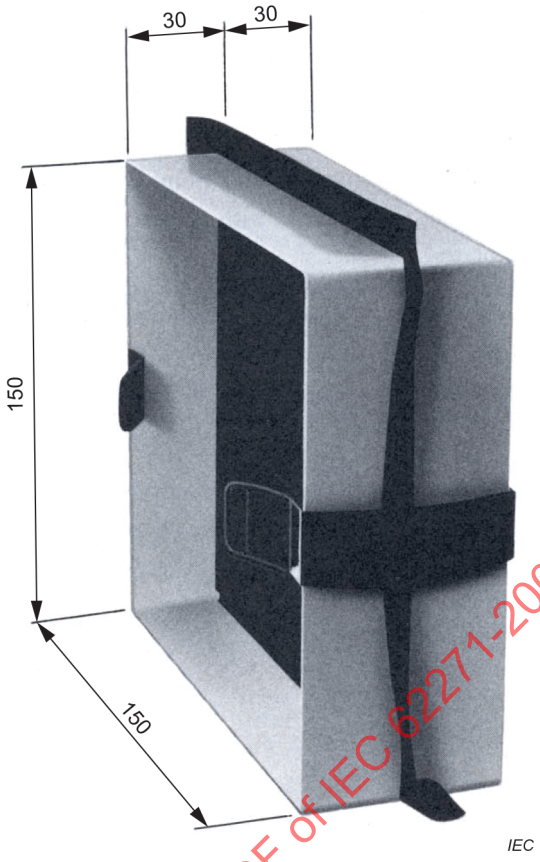


Figure A.1 – Mounting frame for vertical indicators

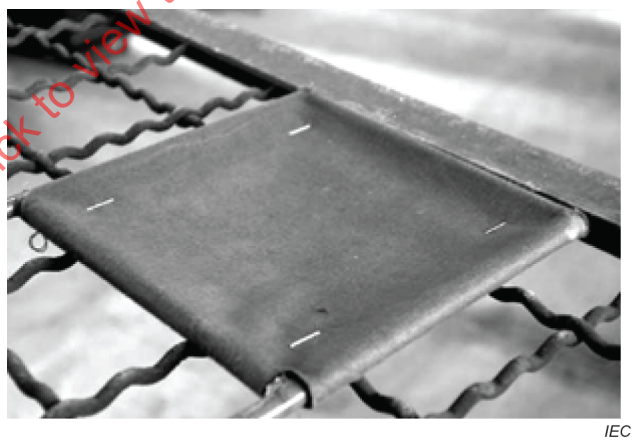
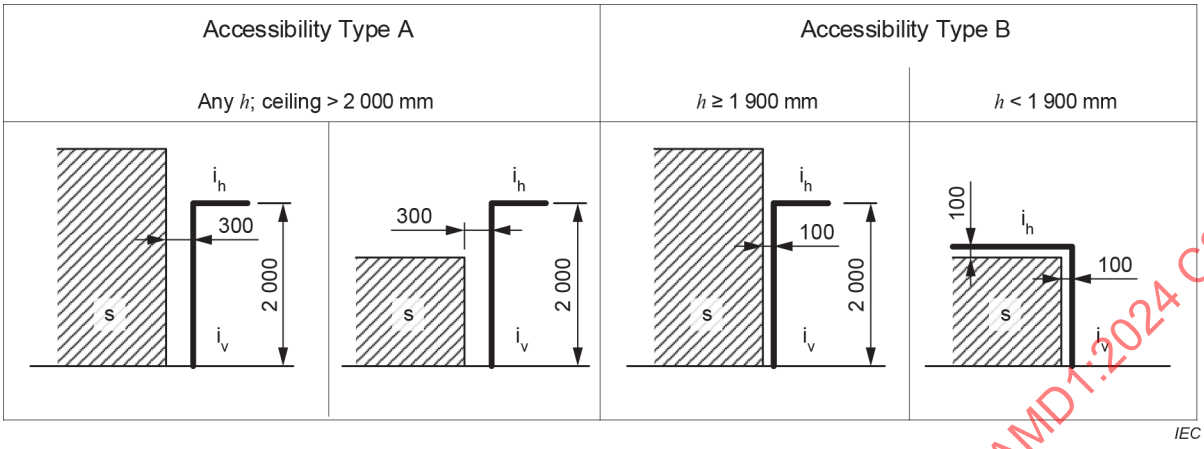


Figure A.2 – Horizontal indicator

Dimensions in millimetres



Key

S Assembly of switchgear and controlgear

h height of switchgear and controlgear

i_h horizontal indicators

i_v vertical indicators

Figure A.3 – Position of the indicators

Dimensions in millimetres

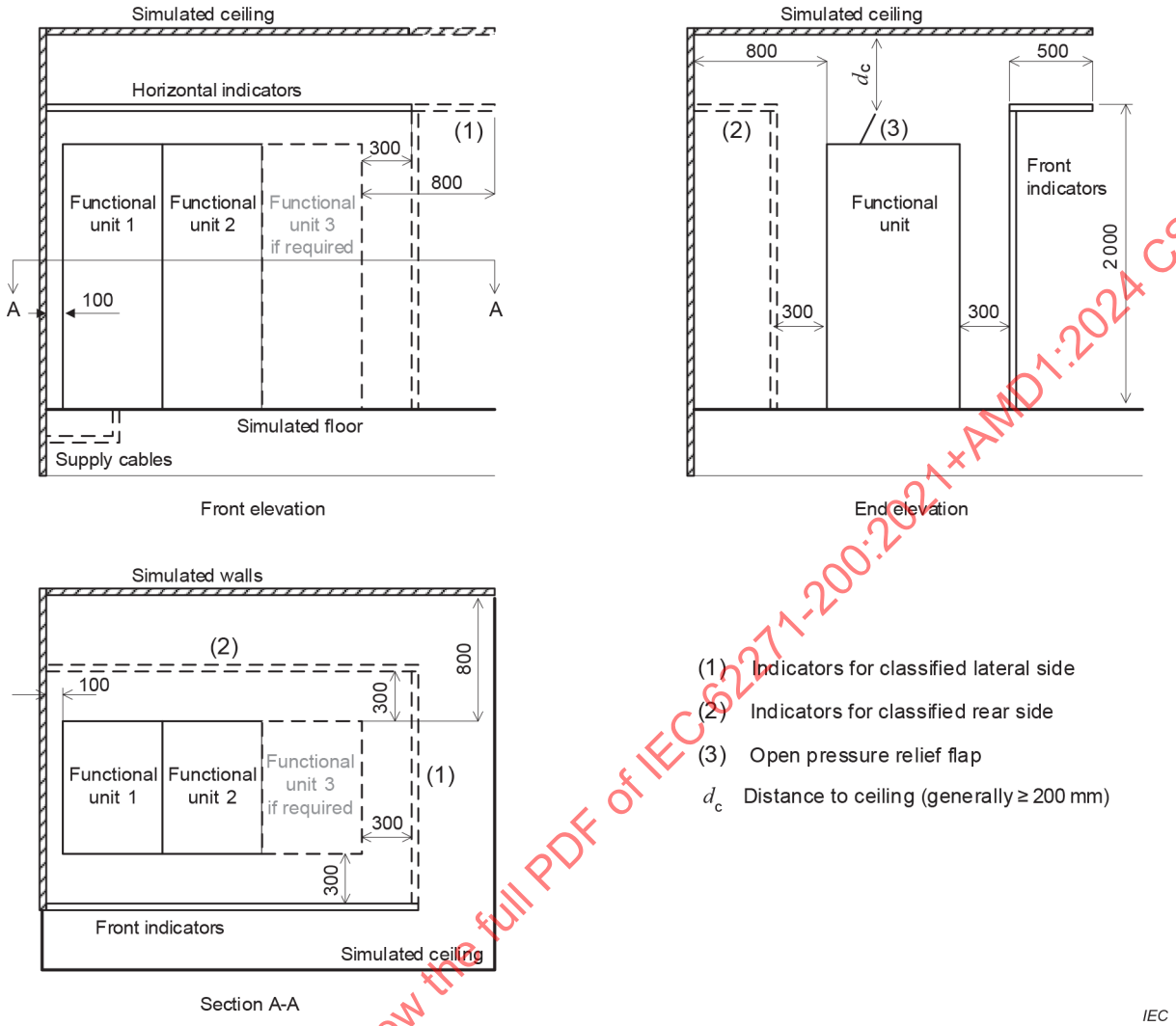


Figure A.4 – Room simulation and indicator positioning for accessibility type A, classified rear side, ceiling above 2 000 mm, functional unit of any height

Dimensions in millimetres

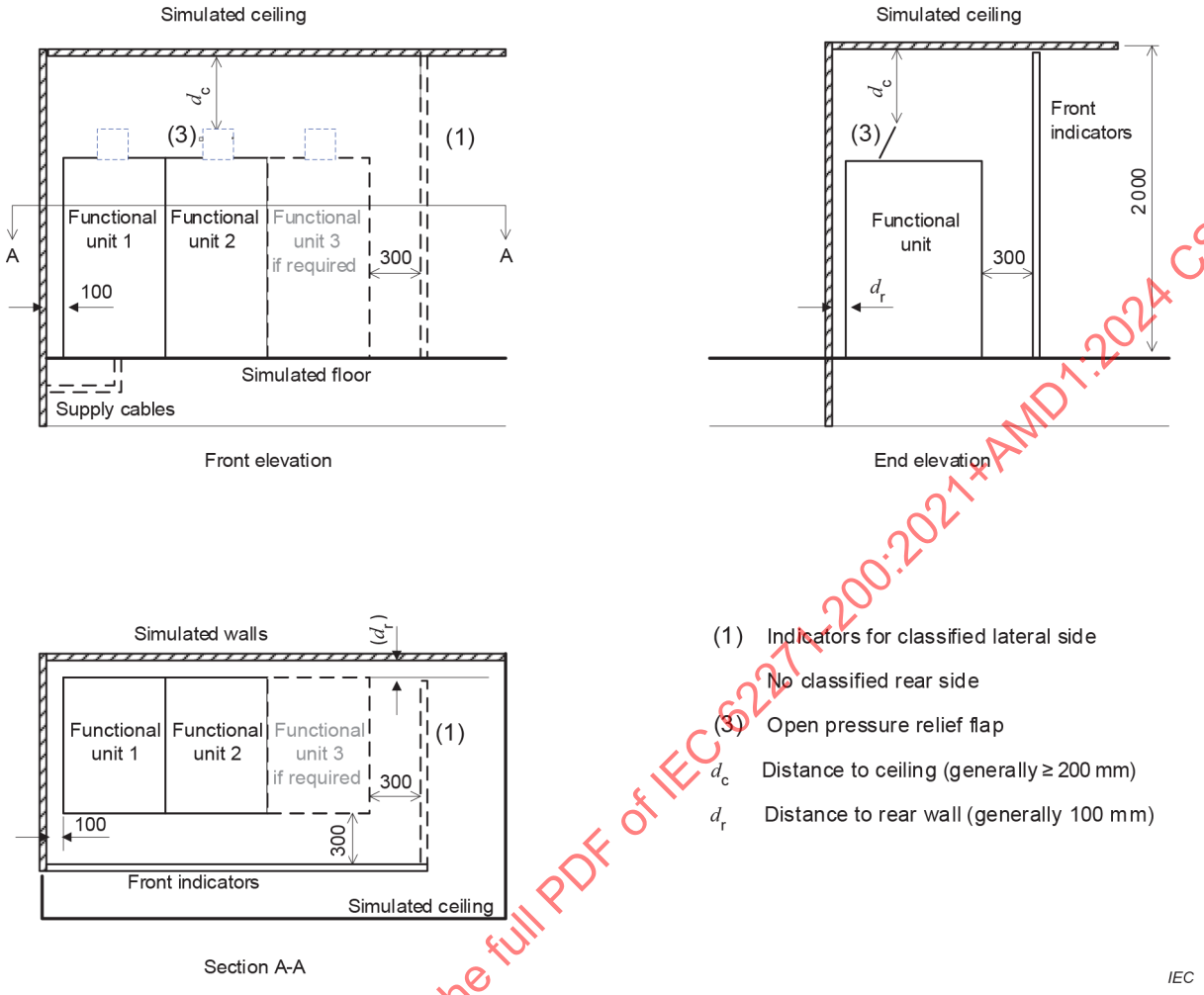


Figure A.5 – Room simulation and indicator positioning for accessibility type A, non-accessible rear side, ceiling at 2 000 mm, so functional unit ≤ 1 800 mm high

Dimensions in millimetres

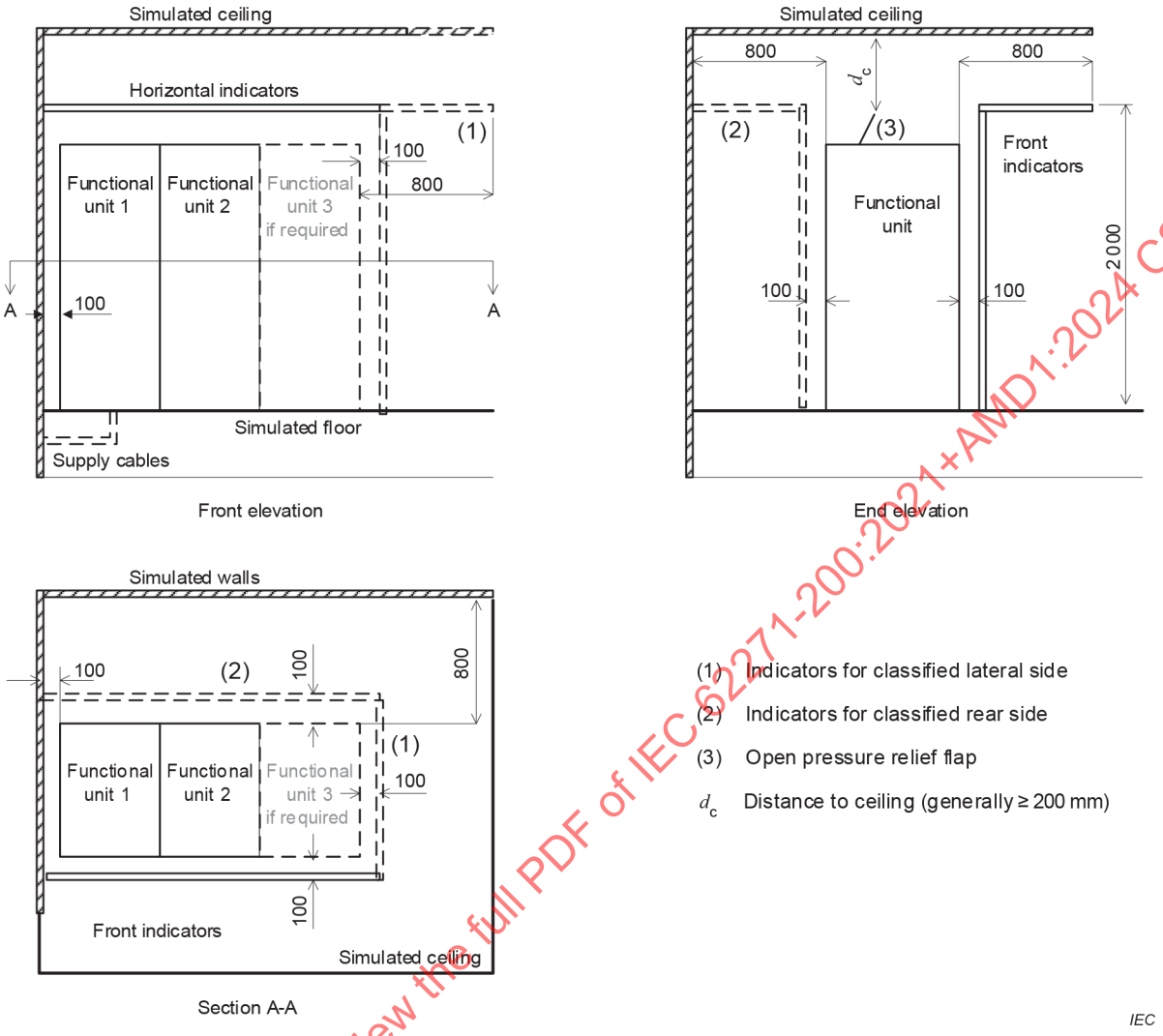


Figure A.6 – Room simulation and indicator positioning for accessibility type B, classified rear side, functional unit ≥ 1 900 mm high

Dimensions in millimetres

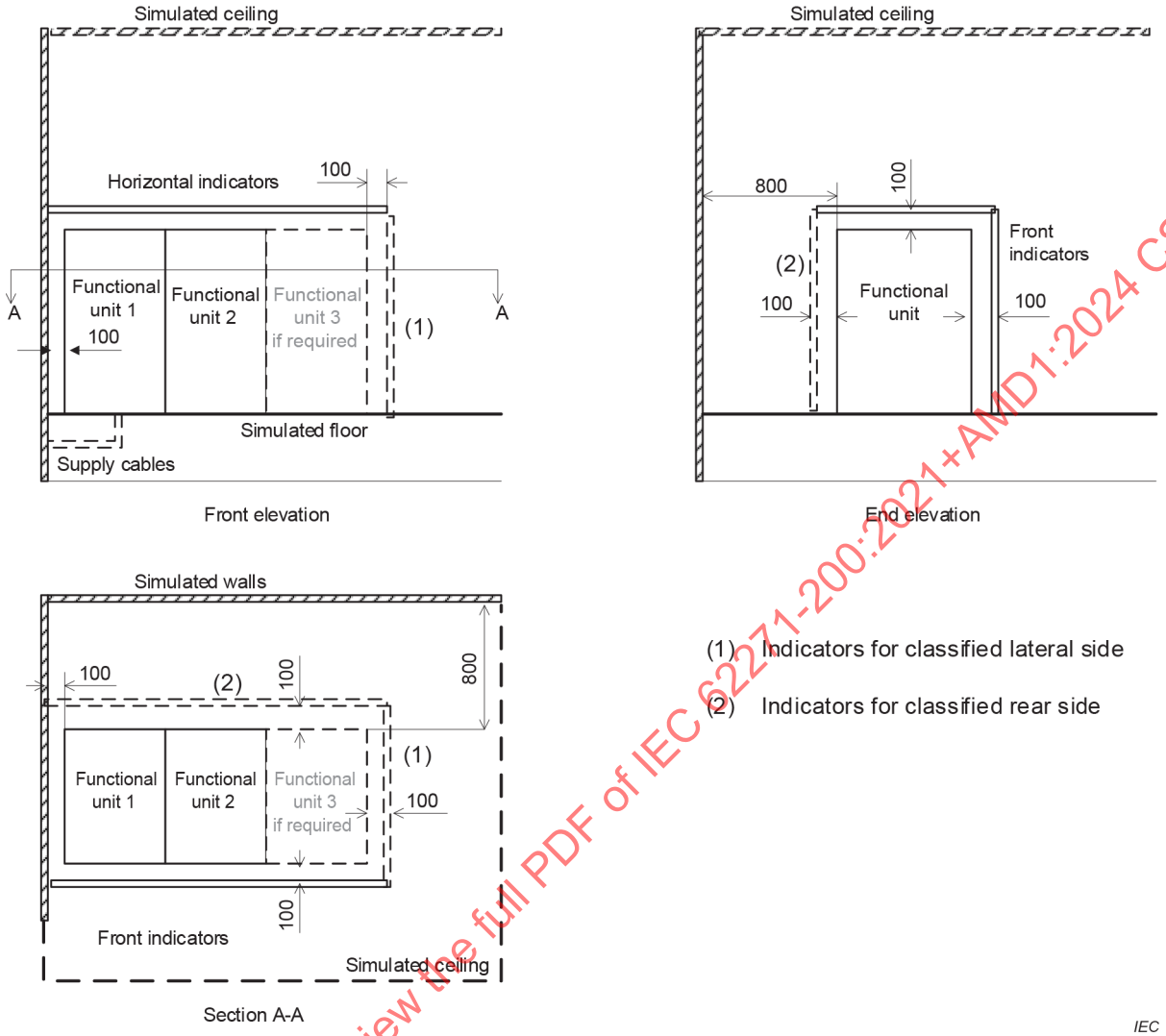
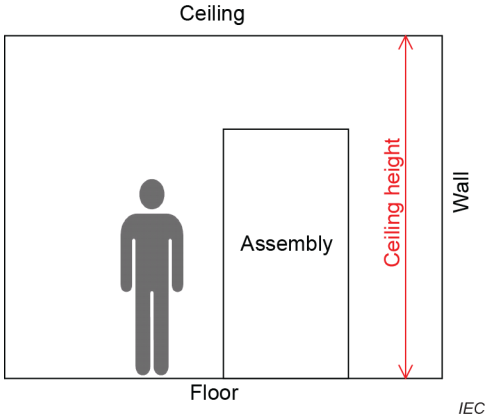
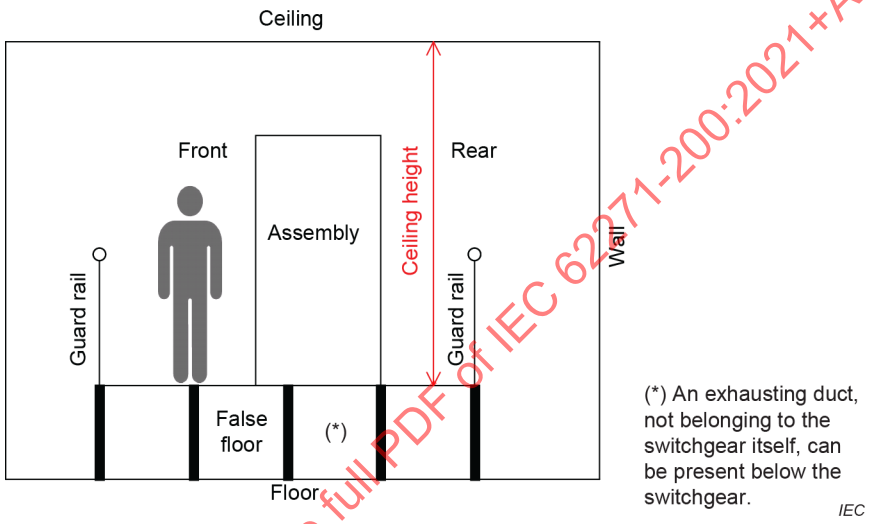


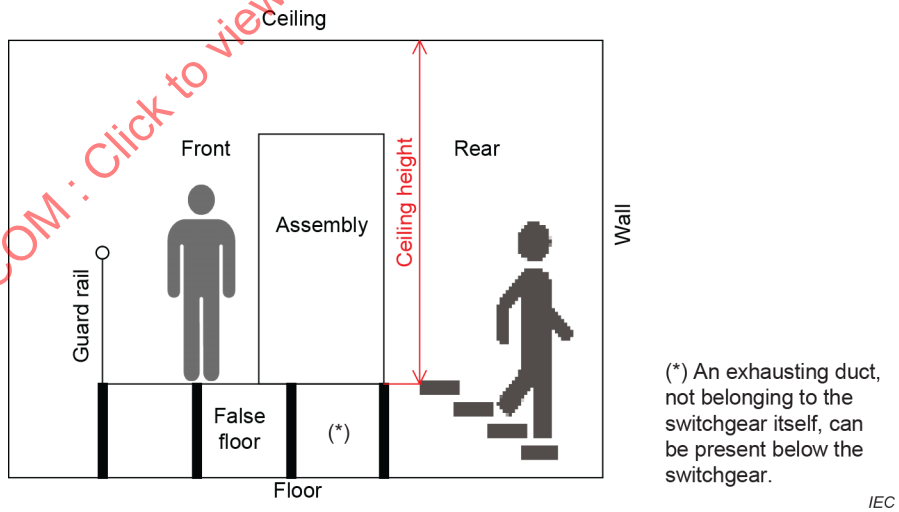
Figure A.7 – Room simulation and indicator positioning for accessibility type B, classified rear side, functional unit < 1 900 mm high



a) Assembly placed on floor

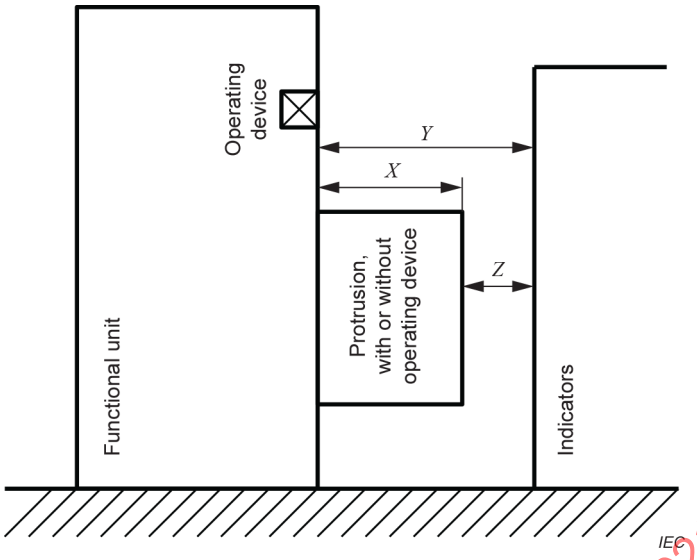


b) Assembly placed on false floor



c) Assembly placed on false floor, floor levels different at front and rear side

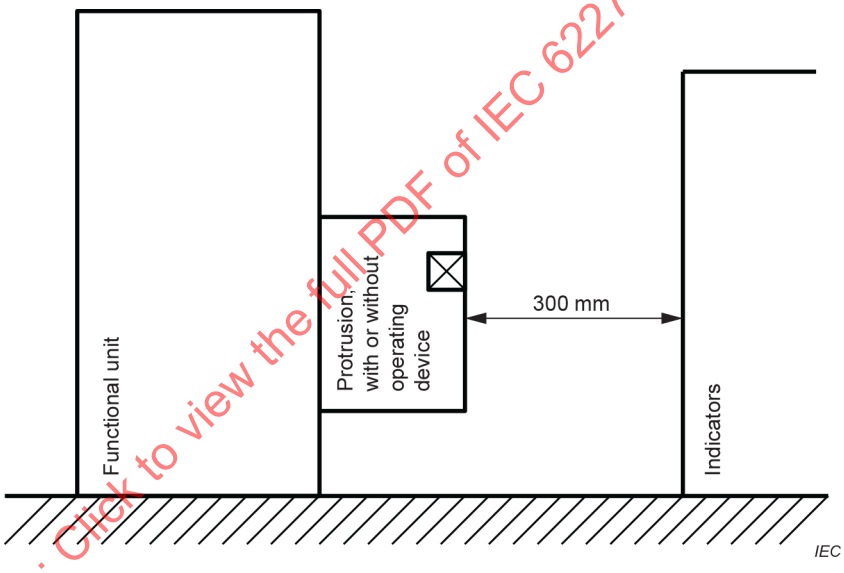
Figure A.8 – Ceiling height stated from the floor or false floor level where the assembly is actually placed



a) At least one operating device (actuator) not located on the protrusion of the classified side:

X < 200 mm: Y = 300 mm

X ≥ 200 mm: Z = 100 mm



b) Protrusion with or without operating device (actuator).

No operating device elsewhere on classified side

Figure A.9 – Indicator positioning in case of protrusion at < 2 000 mm height, at classified side

Dimensions in millimetres

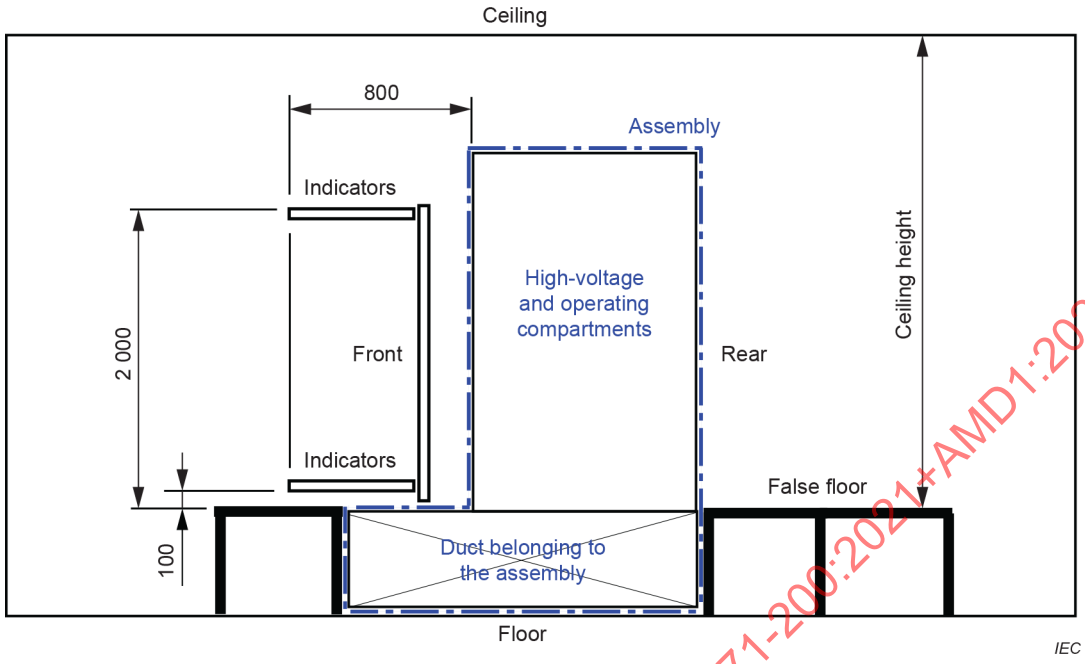


Figure A.10 – Indicator positioning in case a bottom exhaust duct belonging to the assembly is defined as a walkable integrated part of the false floor

Annex B
(normative)

Partial discharge measurement

B.1 General

The measurement of partial discharges is a suitable means of detecting certain defects in the equipment under test and is a useful complement to the dielectric tests. Experience shows that partial discharges can, in particular arrangements, lead to a progressive degradation in the dielectric strength of the solid-insulation inner material, but also of the surface of solid insulating materials when the measured partial discharges correspond to corona discharges in ambient air insulated compartments as well as in fluid-filled compartments where the fluid (gas or liquid) can decompose.

On the other hand, it is not yet possible to establish a reliable relationship between the results of partial discharge measurements and the life expectancy of the equipment owing to the complexity of the insulation systems used in assemblies.

B.2 Application

Because of the design variations, a general specification for the test object cannot be given. In general, the test object should consist of assemblies or subassemblies with dielectric stresses which are identical to those which would occur in the complete assembly of the equipment.

Test objects consisting of a complete assembly are to be preferred. In the case of integrated assembly design, especially where various live parts and connections are embedded in solid-insulation, tests are necessarily carried out on a complete assembly.

NOTE In the case of designs consisting of a combination of conventional components (for instance, instrument transformers, bushings), which 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.

For technical and economic reasons, it is recommended that the partial discharge tests be performed on the same assemblies or subassemblies as are used for the mandatory dielectric tests. 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 during the test.

This test may be carried out on assemblies or subassemblies. Ensure that external partial discharges do not affect the measurement. To prevent these external partial discharges, shielding or grading electrodes may be applied.

Criteria to be considered in deciding on the necessity for a partial discharge test are, for instance:

a) practical experience in service including the results of such testing over a period of production;

b) the value of the electric field strength at the most highly stressed area of the solid-insulation;

c) the type of insulating material used in the equipment as part of the major insulation.

B.3 Test circuits and measuring instruments

The partial discharge tests shall be in accordance with IEC 60270.

Three-phase equipment is either tested in a single-phase test circuit or in a three-phase test circuit (refer to Table B.1) as follows:

a) Single-phase test circuit

– Procedure A

To be used as a general method.

For measuring the partial discharge quantities, each phase shall be connected to the test voltage source successively, the other two phases and all the parts earthed in service being earthed.

– Procedure B

To be used only for equipment exclusively designed for use in systems with solidly earthed neutral.

For measuring the partial discharge quantities, two test arrangements shall be used.

At first, measurements shall be made at a test voltage of 1,1 U_r (U_r is the rated voltage). Each phase shall be connected to the test voltage source successively, the other two phases being earthed. It is necessary to insulate or to remove all the metallic parts normally earthed in service.

An additional measurement shall be made at a reduced test voltage of 1,1 $U_r/\sqrt{3}$ during which the parts being earthed in service are earthed and the three phases connected to the test voltage source are bridged.

b) Three-phase test circuit

When suitable test facilities are available, the partial discharge tests may be carried out in a three-phase arrangement.

In this case, it is recommended to use three coupling capacitors connected as shown in Figure B.1. One discharge detector may be used which is connected successively to the three measuring impedances.

For calibration of the detector on one measuring position of the three-phase arrangement, short-duration current pulses of known charge are injected between each of the phases taken in turn on the one hand, and the earth and the other two phases, on the other hand. The calibration giving the lowest deflection is used for the determination of the discharge quantity.

In the case of equipment designed for use in systems without solidly earthed neutral, an additional test shall be made (as type test only). For this test each phase of the test object and the corresponding phase of the voltage source shall be earthed successively (refer to Figure B.2).

B.4 Test procedure

If performed as type test, the partial discharge tests shall be carried out after the lightning impulse and power-frequency voltage tests of 7.2.7.

If performed as routine test or site test, the partial discharge tests shall be carried out after the power-frequency voltage tests of 8.2.

The applied test-voltage is raised to a pre-stress value of at least 1,3 U_r or 1,3 $U_r/\sqrt{3}$ in accordance with the test circuit (refer to Table B.1) and maintained at this value for at least 10 s.

Partial discharges occurring during this period shall be disregarded. The voltage is then decreased without interruption to 1,1 U_r or 1,1 $U_r/\sqrt{3}$ in accordance with the test circuit and the partial discharge quantity is measured at this test voltage after 10 s (refer to Table B.1).

The test-voltage should comply with 6.2.1.1 of IEC 60060-1:2010. Tests performed for 50 Hz also cover 60 Hz and vice versa.

Voltage transformers should be connected during partial discharge tests, if performed as routine tests.

When performed as type test, components (e.g. fuses, instrument transformers) may be replaced by replicas reproducing their electrical field configuration. Overvoltage protective devices may be disconnected or removed.

When test-voltage is applied on each phase successively, a transformer, a coil, or a similar device normally connected between phases shall be disconnected from the pole stressed with test voltage.

As far as possible with respect to the actual background noise level, the partial discharge inception and the partial discharge extinction voltages should be recorded for additional information.

In general, tests on assemblies or subassemblies should be made with the switching devices in the closed position. In the case of disconnectors where deterioration of the insulation between the open contacts by partial discharges is conceivable, additional partial discharge measurements should be made with the disconnector in the open position.

On fluid-filled equipment, the tests shall be carried out at the minimum functional level or the filling level, whichever is most onerous. For routine tests the filling level shall be applied.

B.5 Maximum permissible partial discharge quantity

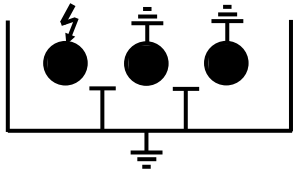
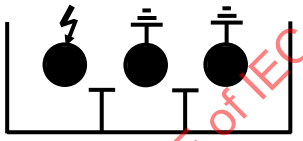
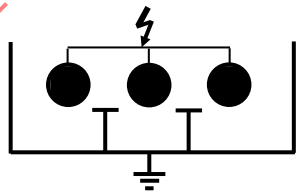
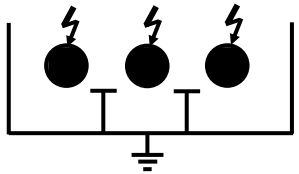
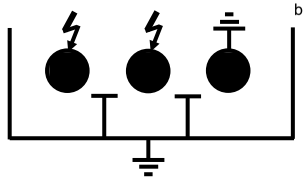
The recommended partial discharge quantity is apparent charge that is expressed in picocoulombs (pC).

The maximum permissible partial discharge quantity at 1,1 U_r and/or 1,1 $U_r/\sqrt{3}$ shall be agreed between the manufacturer and the user.

NOTE 1 Limit values of the partial discharge quantity will not be specified until further substantiated information is available. Components of an assembly can use one or more different technologies (e.g. solid, gas or liquid insulation) each of which has different requirements. It would therefore be very difficult and controversial to specify maximum acceptable levels for general application to the complete, or partial, assembly. For the time being, these values are left to the responsibility of the manufacturer or, in the case of acceptance tests, are subject to agreement between the manufacturer and the user.

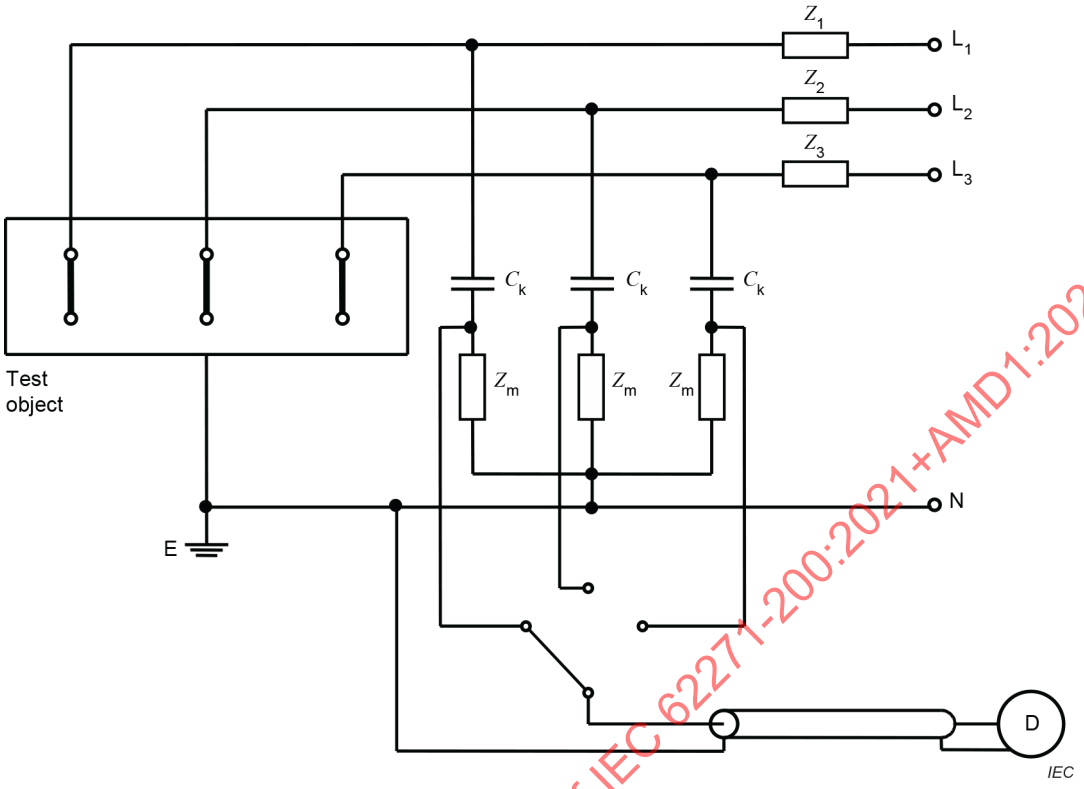
NOTE 2 For solid-insulation, acceptable limits seem to be 20 pC for testing at 1,1 U_r between phases (corresponding with 1,1 $U_r/\sqrt{3}$ phase-to-earth) and in the case of non-solidly earthed neutral system, 100 pC for testing at 1,1 U_r phase-to-earth and the other phases earthed.

Table B.1 – Test circuits and procedures

	Single-phase testing			Three-phase testing
	Procedure A	**Procedure B**		
Voltage source connected to	Each phase successively	Each phase successively	Three phases simultaneously	Three phases (Figure B.1 and Figure B.2)
Earth-connected elements	Both the other phases and all the parts earthed in service	Both the other phases	All the parts earthed in service	All the parts earthed in service
Minimum pre-stress voltage	1,3 U_r	1,3 U_r	1,3 $U_r/\sqrt{3}$	1,3 U_r [a]
Test voltage	1,1 U_r	1,1 U_r	1,1 $U_r/\sqrt{3}$	1,1 U_r [a]
Basic diagram				  [b]

[a] Voltage between phases.

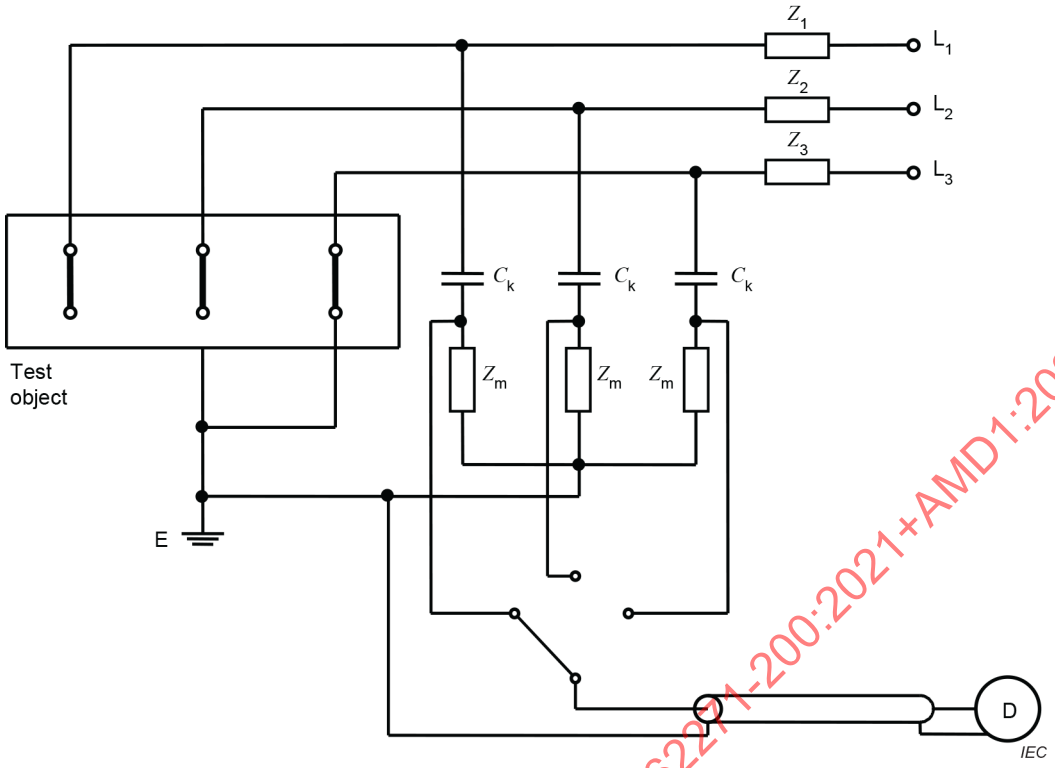
[b] Additional test in the case of a system without solidly earthed neutral (for type tests only).



Key

N	neutral connection
E	earth connection
L_1, L_2, L_3	terminals for the connection of the three-phase voltage source
Z_1, Z_2, Z_3	impedances of the test circuit
C_k	coupling capacitance
Z_m	measuring impedance
D	partial discharge detector

Figure B.1 – Partial discharge test circuit (three-phase arrangement)



Key

E	earth connection
L_1, L_2, L_3	terminals for the connection of the three-phase voltage source
Z_1, Z_2, Z_3	impedances of the test circuit
C_k	coupling capacitance
Z_m	measuring impedance
D	partial-discharge detector

Figure B.2 – Partial-discharge test circuit (system without earthed neutral)

Annex C
(informative)

List of notes concerning certain countries

6.104 In Canada, regulations require that the isolating distance is visible.

5.11 In Italy, the Italian pressure vessel code for electrical switchgear DM 1 December 1980 and DM 10 September 1981 published in Gazzetta Ufficiale della Repubblica Italiana n° 285 dated 16.10.1981 applies:

For metal-enclosed switchgear and controlgear containing gas-filled compartments, the design pressure is limited to a maximum of 0,5 bar (gauge) and the volume is limited to a maximum of 2 m^3. Gas-filled compartments having a design pressure exceeding 0,5 bar (gauge) or a volume exceeding 2 m^3 shall be designed according to the Italian pressure vessel code for electrical switchgear.

Annex D
(normative)

Flowchart categorization procedure for LSC for a given functional unit FU1 with connection compartment

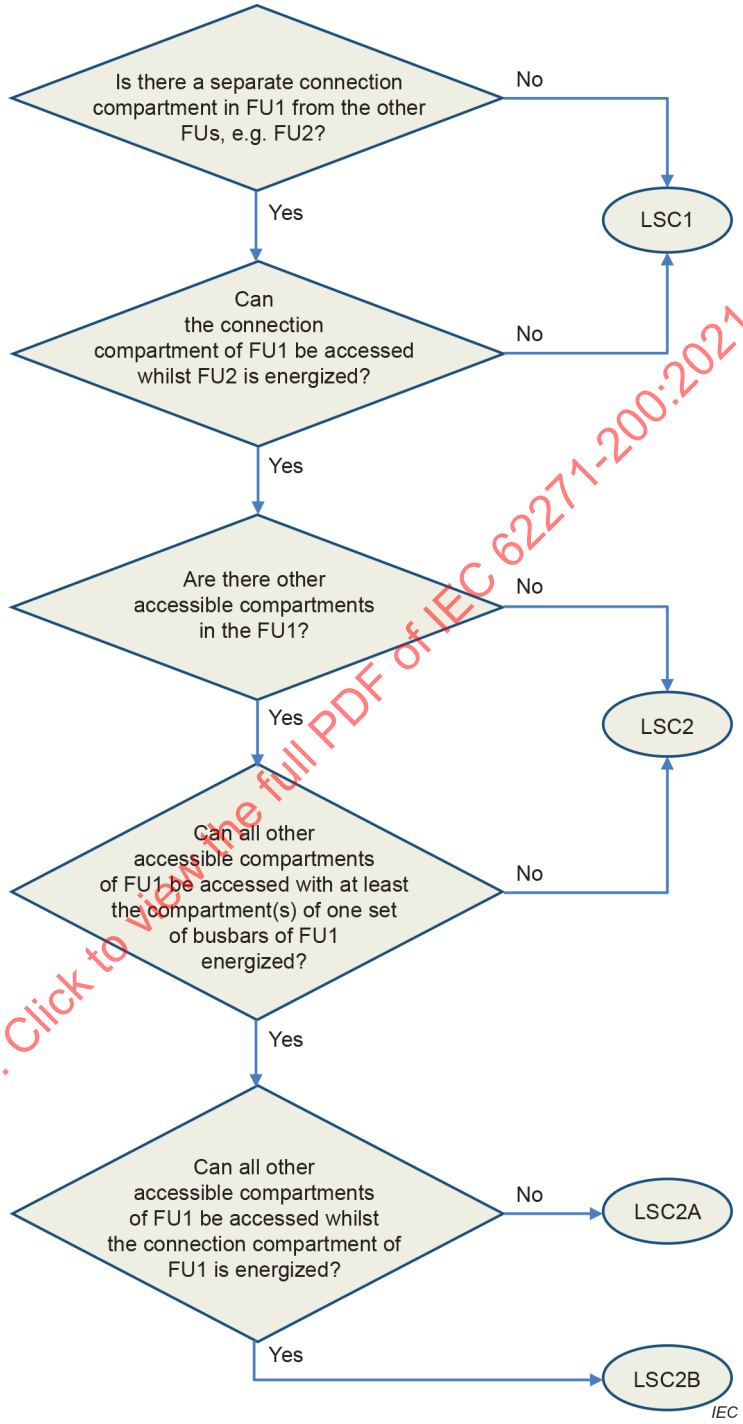
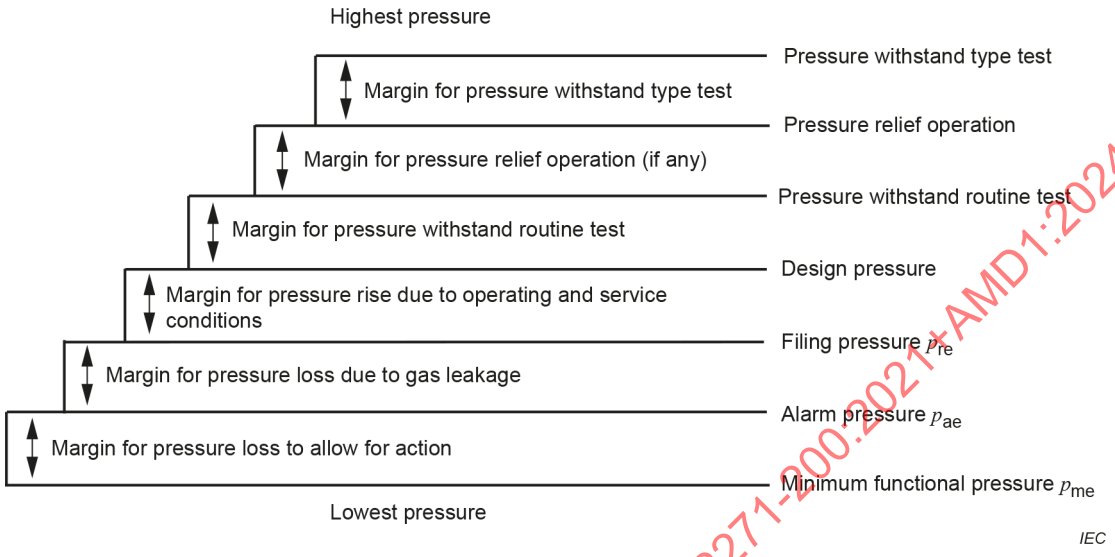


Figure D.1 – Flowchart categorization procedure for LSC for a given functional unit FU1 with connection compartment

Annex E
(informative)

Pressure coordination chart for gas-filled compartments



NOTE To be comparable, all pressures are represented as relative pressures in this figure.

Figure E.1 – Example of pressure coordination chart

Bibliography

[1] IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Part 601: Generation, transmission and distribution of electricity – General* (available at http://www.electropedia.org)

[2] IEC TS 62271-304:2019, *High-voltage switchgear and controlgear – Part 304: Classification of indoor enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV related to the use in special service conditions with respect to condensation and pollution*

[3] IEEE 400.2:2013, *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz)*

[4] IEC 62271-214:2019, *High-voltage switchgear and controlgear – Part 214: Internal arc classification for metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

[5] IEEE C37.20.7:2017, *IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults*

[6] IEC 60059:1999, *IEC standard current ratings*
IEC 60059:1999/AMD1:2009

[7] IEC 62271-4:2013, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF_6) and its mixtures*

[8] IEC 60724:2000, *Short-circuit temperature limits of electric cables with rated voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV)*
IEC 60724:2000/AMD1:2008

[9] IEC 60243-1:2013, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

[10] IEC TR 62271-307:2015, *High-voltage switchgear and controlgear – Part 307: Guidance for the extension of validity of type tests of AC metal and solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

[11] Cigré Technical Brochure 686:2017, *Mitigating the Effects of Arcs in M.V. Switchgear, ISBN 978-2-85873-389-7*

[12] IEC 60909-0:2016, *Short-circuit currents in three-phase AC systems – Part 0: Calculation of currents*

[13] ISO IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

[14] EN 50187:1996, *Gas-filled compartments for AC switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62271-200 edition 3.1 contains the third edition (2021-05) [documents 17C/782/FDIS and 17C/792/RVD] and its amendment 1 (2024-06) [documents 17C/933/FDIS and 17C/938/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

IEC 62271-200 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

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

a) clause numbering aligned with IEC 62271-1:2017, including the adoption of the subclause names of Clause 3;
b) in Clause 3 specific definitions are added for "in service", "normal operating condition" and "normal use";
c) internal arc testing on pole-mounted switchgear is taken out of this document, as it is now covered by the specific standard IEC 62271-214:2019;
d) a more precise description of earthing circuit is given with the inclusion of ratings and test requirements;
e) number of mechanical tests on interlocks is reduced for type testing; a more precise description of forces to apply during type testing is given (refer to 7.102);
f) resistance measuring on main circuit is only needed before continuous current tests (as reference for routine tests) and no longer needed after this continuous current test. Rationale for this deletion is that this measured resistance does not mean anything; as the temperature rise test was just finished, a new temperature rise test will not give new information;
g) IEC 62271-100:2021, IEC 62271-103:2021, IEC 62271-105:2021 and IEC 62271-106:2021 are referred to in the document;
h) IEC 62271-107:2019 and IEC IEEE 62271-37-013:2015 are also considered in 7.101.2;
i) a more precise description of LSC category is given with the inclusion of an explanatory flowchart (Annex D);
j) examples not covered by the IAC test are transferred from Clause 6 to 9.103;
k) the term "assembly" is defined in Clause 3 and used as synonym for "metal-enclosed switchgear and controlgear" in this document;
l) "metallic" is replaced by "metal" where applicable;
m) 6.105 is now covered by 7.7;
n) a 1 s rule was introduced for Criterion 4 during IAC tests regarding hot gases versus glowing particles as cause of ignition;
o) a more precise description of internal arc tests for switchgear with protrusions is given in Annex A.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This document should be read in conjunction with IEC 62271-1:2017, 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 62271-1:2017. 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 C lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

A list of all parts in the IEC 62271 series, published under the general title *High-voltage switchgear and controlgear*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

High-voltage (IEC 60050-601:1985, 601-01-27) switchgear refers to rated voltages above 1 kV. However, medium-voltage is commonly used for distribution systems with rated voltages above 1 kV and generally applied up to and including 52 kV; refer to IEC 60050-601:1985, 601-01-28 [1][1].

Although primarily dedicated to three-phase systems, this document can also be applied to single-phase and two-phase systems.

Switchgear and controlgear assemblies having a solid-insulation enclosure are covered by IEC 62271-201.

Generally, gas-filled medium-voltage designs have design pressures below 500 kPa, as mentioned for example in the introduction of EN 50187.

1 Numbers in square brackets refer to the Bibliography.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

1 Scope

This part of IEC 62271 is applicable to prefabricated metal-enclosed switchgear and controlgear assemblies designed for:

– alternating current;
– rated voltages above 1 kV and up to and including 52 kV;
– service frequencies up to and including 60 Hz;
– indoor and outdoor installation.

The assembly can include air-insulated and/or fluid-filled compartments.

For components installed in a metal-enclosed switchgear and controlgear, this document supplements or even replaces in some cases, the requirements as stated by the individual product standards.

The list of components which can be inside the metal-enclosed switchgear and controlgear is not limited to the ones explicitly cited in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at http://www.electropedia.org)

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at http://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 60270:2000/AMD1:2015

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

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

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-100:2021, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

IEC 62271-102:2018, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-103:2021, *High-voltage switchgear and controlgear – Part 103: Switches for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-105:2021, *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 62271-106:2021, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

IEC 62271-107:2019, *High-voltage switchgear and controlgear – Part 107: Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV*

IEC 62271-201:2014, *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*

IEC 62271-213:2021, *High-voltage switchgear and controlgear – Part 213: Voltage detecting and indicating system*

IEC 62271-215:2021, *High-voltage switchgear and controlgear – Part 215: Phase comparator used with VDIS*

IEC IEEE 62271-37-013:2015, *High-voltage switchgear and controlgear – Part 37-013: Alternating-current generator circuit-breakers*

ISO 4126-2, *Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices*

3 Terms and definitions

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

NOTE The classification system for definitions of IEC 62271-1:2017 is followed. Terms and definitions are referenced and prioritized in the following order:

– Clause 3 of this document;
– IEC 62271-1:2017;
– IEC 60050-441;
– IEC 60050-151.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General terms and definitions

The definitions in 3.1 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.1.101
ambient air temperature
<of an assembly> temperature, determined under specified conditions, of the air surrounding the enclosure of an assembly

[SOURCE: IEC 60050-441:1984, 441-11-13, modified – "prescribed" has been replaced by "specified", "complete switching device or fuse" by "enclosure of an assembly" and the note has been removed.]

3.1.102
disruptive discharge
phenomenon 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 is applicable 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 can 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 gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

3.1.103
relative pressure
pressure that refers to the local atmospheric pressure

Note 1 to entry: When defining a filling level it is in reference to the standard atmospheric pressure of 101,3 kPa, as defined in IEC 62271-1.

3.1.104
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 can be established between the conductors as well as between the open contacts of a switching device like a disconnector.

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

[SOURCE: IEC 60050-441:1984, 441-11-11, modified – Notes to entry have been added.]

3.1.105
in service
<condition of an assembly> condition where at least one high voltage part in the assembly is energized

3.1.106
normal operating condition
<of an assembly> in service condition with all doors and covers properly closed and secured

3.1.107
normal use
<of an assembly> use of the assembly as defined by the manufacturer's instructions reference, corresponding to the conditions and operations in service

Note 1 to entry: "normal use" may include maintenance activities within an accessible high-voltage compartment.

3.2 Assemblies of switchgear and controlgear

The definitions in 3.2 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.2.101
metal-enclosed switchgear and controlgear assembly
switchgear and controlgear assemblies with a metal enclosure intended to be earthed, and complete except for external connections

Note 1 to entry: This term generally is applicable to high-voltage switchgear and controlgear.

Note 2 to entry: The term "external connections" corresponds to "external conductors (cables or bars) connecting the assembly to the network or an external installation".

[SOURCE: IEC 60050-441:1984, 441-12-04, modified – The second preferred term "assembly" and Note 2 to entry have been added and in the definition "external" has been deleted.]

3.2.102
multi-tier design
design of an assembly in which the main switching devices of two or more functional units are arranged vertically (one above the other) within a common enclosure

3.3 Parts of assemblies

The definitions in 3.3 of IEC 62271-1:2017 are applicable.

3.4 Switching devices

The definitions in 3.4 of IEC 62271-1:2017 are applicable.

3.5 Parts of switchgear and controlgear

The definitions in 3.5 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.5.101
enclosure
<of an assembly> part of an assembly providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

[SOURCE: IEC 60050-441:1984, 441-13-01]

3.5.102
metal enclosure
<of an assembly> outermost enclosure made of metal, which can be composed of several elements, enclosing all high-voltage parts

3.5.103
functional unit
<of an assembly> part of an assembly comprising the main circuits, earthing circuit and auxiliary circuits that contribute to the fulfilment of a single function

Note 1 to entry: Functional units can be distinguished according to the function for which they are intended, e.g., incoming unit, through which electrical energy is normally fed into the assembly, outgoing unit, through which electrical energy is normally supplied to one or more external circuits

[SOURCE: IEC 60050-441:1984, 441-13-04, modified – "of switchgear and controlgear" and "all the components of" have been deleted; "earthing circuit" has been added.]

3.5.104
component
<of an assembly> essential part of the high-voltage or earthing circuits of an assembly which serves a specific function (e.g. circuit-breaker, disconnector, switch, fuse, earthing switch, instrument transformer, bushing, busbar)

3.5.105
main circuit
<of an assembly> all the high-voltage conductive parts of an assembly included in a circuit which is intended to carry the rated continuous current

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – "high voltage" is added and "transmit electrical energy" is replaced by "carry the rated continuous current".]

3.5.106
auxiliary circuit
<of an assembly> all the conductive parts of an assembly of 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 an assembly include the control and auxiliary circuits of the switching devices.

[SOURCE: IEC 60050-441:1984, 441-13-03, modified – "main circuit" is replaced by "high-voltage parts".]

3.5.107
earthing circuit
<of an assembly> conductors, connections, and the conducting parts of earthing devices or of the metal frame, intended to connect the high-voltage conductive parts of an assembly to the earthing point provided

Note 1 to entry: The earthing circuit can include short-circuiting circuits between poles and phase-to-earth circuits from each pole to the earthing point and/or from the short-circuiting point of phase-to-earth circuits to the earthing point provided.

3.5.108
earthing point
<of an assembly> terminal which is provided on the assembly for connection of the intended earthed parts of the assembly to the earth system of the installation

3.5.109
high-voltage compartment
<of an assembly> compartment of an assembly containing high-voltage conducting parts, enclosed except for openings necessary for interconnection, control or ventilation

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

3.5.110
interlock-controlled accessible compartment
high-voltage compartment designed to be opened for normal use, in which access is controlled by the integral design of the assembly

3.5.111
procedure-based accessible compartment
high-voltage compartment designed to be opened for normal use, in which access is controlled by a suitable procedure combined with locking

3.5.112
tool-based accessible compartment
high-voltage compartment that can be opened only through the use of tools, but not designed to be opened for normal use

3.5.113
non-accessible compartment
high-voltage compartment that is designed not to be opened by the user

Note 1 to entry: By default, every high-voltage compartment not declared accessible by the manufacturer in the manufacturer's instructions reference, is considered as a non-accessible compartment.

3.5.114
fluid-filled compartment
high-voltage compartment of an assembly, filled with a fluid, either gas, other than ambient air, or liquid, for insulation purposes

Note 1 to entry: For fluid-filled compartments with gas, the term "gas-filled compartment" is used.

Note 2 to entry: The pressure is maintained by one of the following systems:

a) controlled pressure system;

b) closed pressure system;

c) sealed pressure system.

Note 3 to entry: For pressure systems, refer to 3.6.6 of IEC 62271-1:2017.

3.5.115
pressure relief device
device intended to relieve overpressure from a compartment

3.5.116
partition
<of an assembly> part of an assembly separating one high-voltage compartment from other compartments and providing a specified degree of protection

Note 1 to entry: Partitions can be fitted with parts that allow interconnection between compartments (e.g. bushings).

[SOURCE: IEC 60050-441:1984, 441-13-06, modified – "high-voltage" and "and providing a specified degree of protection" have been added.]

3.5.117
bushing
insulator forming a passage for a conductor through a non-insulating partition

[SOURCE: IEC 60050-151:2001, 151-15-40]

3.5.118
shutter
<of an assembly> part of an assembly that can be moved from a position where it permits contacts of a removable part, or moving contact of a disconnector, to engage fixed contacts, to a position where it becomes a part of the enclosure or partition shielding the fixed contacts

[SOURCE: IEC 60050-441:1984, 441-13-07, modified – "moving contact of a disconnector" has been added.]

3.5.119
removable part
<of an assembly> part of an assembly that may be removed entirely from the assembly and replaced

[SOURCE: IEC 60050-441:1984, 441-13-08, modified – "even though the main circuit is alive" has been deleted.]

3.5.120
withdrawable part
<of an assembly> removable part of an assembly that can be moved to one or more positions in which an isolating distance or a segregation between open contacts is established, while the part remains mechanically attached to the assembly, even though the main circuit to which it was connected is live

[SOURCE: IEC 60050-441:1984, 441-13-09, modified – "even though the main circuit to which it was connected is live" has been added; the Note has been deleted.]

3.5.121
fuse-link
the part of a fuse (including the fuse-element(s)) intended to be replaced after the fuse has operated

Note 1 to entry: In this document the term is exclusively used in relation with high-voltage fuses.

[SOURCE: IEC 60050 441:1984, 441-18-09, modified – The Note to entry has been added.]

3.6 Operational characteristics of switchgear and controlgear

The definitions in 3.6 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.6.101
loss of service continuity category
LSC
<of a functional unit> category defining the possibility to keep other high-voltage compartments and/or functional units energized when opening its connection compartment or any other of its high-voltage compartment(s) accessible in normal use, as stated in definitions 3.5.110 and 3.5.111, giving access to at least part of the high-voltage circuit contained within

Note 1 to entry: The LSC category describes the extent to which the assembly is intended to remain operational where access to a high-voltage compartment is provided. The extent to which it is considered necessary to open high-voltage compartments of an installation in service might be dependent on several aspects (refer to 9.101).

Note 2 to entry: The LSC category does not describe or relate to different levels of reliability of assemblies (refer to 9.101).

Note 3 to entry: In relation to providing access to high-voltage compartments and the associated service continuity, four categories are defined: LSC1, LSC2, LSC2A, LSC2B (refer to Annex D).

3.6.102
category LSC2
<of a functional unit> category of functional units having at least a separate accessible compartment for the high-voltage connection of that functional unit (called connection compartment), such that, when this compartment is open, at least one busbar may remain energized and all other functional units of the assembly may be operated normally

3.6.103
category LSC2A
<of a functional unit> category of functional units of category LSC2 such that, when any accessible compartment (other than its connection compartment and the busbar compartment

of single-busbar assemblies) is open, at least one busbar may remain energized and all other functional units of the assembly may be operated normally

3.6.104
category LSC2B
<of a functional unit> category of functional units of category LSC2A, where the high-voltage connections (e.g. cable connections) to the functional unit may remain energized when any other accessible high-voltage compartment (other than its connection compartment and the busbar compartment of single-busbar assemblies) of the corresponding functional unit is open

3.6.105
category LSC1
<of a functional unit> category of functional units 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 shall not remain energized

3.6.106
partition class
<of an assembly> class defining whether only metal or also non-metal material is used for partitions

3.6.107
class PM
<of an assembly> partition class for an assembly providing continuous metal partitions and/or shutters (if applicable), intended to be earthed, between opened accessible compartments and high-voltage live parts

3.6.108
class PI
<of an assembly> partition class for an assembly having one or more non-metal partitions or shutters between opened accessible compartments and high-voltage live parts

3.6.109
service position
connected position
<of a removable part> position of a removable part in which it is fully connected for its intended function

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

3.6.110
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]

3.6.111
disconnected position
isolated position
<of a withdrawable part> position of a withdrawable part in which an isolating distance or segregation is established in all the circuits of the withdrawable part, that part remaining mechanically attached to the assembly

Note 1 to entry: In enclosed high-voltage switchgear and controlgear, the auxiliary circuits are generally not disconnected.

[SOURCE: IEC 60050-441:1984, 441-16-28, modified – In the Note 1 to entry, "may not be" has been replaced by "are generally not".]

3.6.112
removed position
<of a removable part> position of a removable part when it is outside and mechanically and electrically separated from the assembly

[SOURCE: IEC 60050-441:1984, 441-16-29]

3.6.113
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

Note 1 to entry: Refer to 3.3 of IEC 60529:1989.

3.6.114
minimum functional level
<of fluid-filled compartments> pressure (or density) according to definitions 3.6.5.5 and 3.6.5.6 of IEC 62271-1:2017, or liquid mass at and above which the rated values of the assembly are maintained

3.6.115
design pressure
<of fluid-filled compartments> upper limit of the relative pressure between the pressure inside a compartment at the design temperature, under defined installation conditions, and the pressure outside that compartment, that is used to determine the design of the compartment.

Note 1 to entry: The transient pressure occurring during and after a breaking operation (e.g. circuit-breaker) is not considered in the determination of the design pressure.

3.6.116
design temperature
<of fluid-filled compartments> highest average temperature over the compartment, which can be reached by the gas or liquid under service conditions

3.6.117
internal arc classification
IAC
<of an assembly> classification of an assembly for which specified criteria, for protection of persons, are met in the event of internal arc for specified installation conditions, as demonstrated by type tests

Note 1 to entry: The internal arc classification is completed with the characteristics indicated in definitions 3.6.118, 3.6.119, 3.7.101 and 3.7.102.

3.6.118
type of accessibility
<of IAC> characteristic related to the level of protection given to people accessing a defined area around the enclosure of an assembly in the event of internal arc

3.6.119
classified sides
<of IAC> accessible sides of the assembly having a defined level of protection of persons in the event of internal arc

3.7 Characteristic quantities

The definitions in 3.7 of IEC 62271-1:2017 are applicable, with the following additions and/or modifications:

3.7.101
arc fault current
<of IAC> three-phase and, where applicable, the single-phase-to-earth RMS value of the internal arc fault current for which the assembly is designed to protect persons in the event of an internal arc

3.7.102
arc fault duration
<of IAC> duration of the internal arc fault current for which the assembly is designed to protect persons in the event of an internal arc

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4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 is applicable with the following addition:

Unless otherwise specified in this document, the assembly is designed to be used under normal service conditions.

Assemblies, under the scope of IEC TS 62271-304:2019 [2] and intended to be used in service conditions more severe with respect to condensation and pollution than the normal service conditions specified in this document, can be classified as "class 1" or "class 2" according to IEC TS 62271-304:2019 to indicate its ability to withstand such severe conditions.

NOTE IEC TS 62271-304:2019 proposes, to gain experience, further classes for service conditions with associated testing procedure in its informative Annex E.

5 Ratings

5.1 General

Subclause 5.1 of IEC 62271-1:2017 is applicable with the following additions:

k) rated short-time withstand current for earthing circuits (I_{ke});

l) rated peak withstand current for earthing circuits (I_{pe});

m) rated duration of short-circuit for earthing circuits (t_{ke});

n) ratings of the components forming part of the assembly including their operating devices and auxiliary equipment;

Optional ratings:

o) rated voltage for AC cable test voltage ($U_{ct\ (AC)}$);

p) rated voltage for DC cable test voltage ($U_{ct\ (DC)}$);

q) rated duration for DC cable test voltage ($t_{ct\ (DC)}$);

r) ratings of the internal arc classifications (IAC).

5.2 Rated voltage (U_r)

Subclauses 5.2.1 and 5.2.2 of IEC 62271-1:2017 are applicable.

NOTE Components forming part of an assembly can have individual values of rated voltage in accordance with their relevant standards.

5.3 Rated insulation level (U_d, U_p, U_s)

Subclause 5.3 of IEC 62271-1:2017 is applicable.

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2017 is applicable.

5.5 Rated continuous current (I_r)

Subclause 5.5 of IEC 62271-1:2017 is applicable with the following addition:

Some main circuits of an assembly (e.g. busbars, feeder circuits) may have different values of rated continuous current.

5.6 Rated short-time withstand currents (I_k, I_{ke})

Subclause 5.6 of IEC 62271-1:2017 is applicable with the following additions:

5.6.101 Rated short-time withstand current (I_k)

In principle, an assembly has one rated short-time withstand current value. However, there are several situations where it is permissible to assign different rated short-time withstand current values to different portions of the main circuit, including:

- circuits protected by current-limiting fuses;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated short-time withstand current values (I_k) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated short-time withstand phase-to-earth current (I_{ke}) shall be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

NOTE The short-circuit current ratings assigned to the earthing circuit define the possible earthing conditions of the system neutral of the network on which the assembly can be installed. Refer to 9.102.

5.7 Rated peak withstand currents (I_p, I_{pe})

Subclause 5.7 of IEC 62271-1:2017 is applicable with the following additions:

5.7.101 Rated peak withstand current (I_p)

In principle, an assembly has one rated peak withstand current value. However, there are several situations where it is permissible to assign different rated peak withstand current values to different portions of the main circuit, including:

- circuits protected by current-limiting fuses;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated peak withstand current values (I_p) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated peak phase-to-earth withstand current (I_{pe}) shall be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

5.8 Rated durations of short-circuit (t_k, t_{ke})

Subclause 5.8 of IEC 62271-1:2017 is applicable with the following additions:

5.8.101 Rated duration of short-circuit (t_k)

In principle, an assembly has one rated duration of short-circuit. However, there are several situations where it is permissible to assign different rated durations of short-circuit to different portions of the main circuit including:

- circuits protected by current-limiting fuses and/or circuit-breakers;
- circuits under interlocked switching devices commutating two branches of a circuit.

The rated short-time withstand current values (t_k) assigned to the assembly are also applicable to the short-circuiting parts of the related earthing circuits, including earthing devices.

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

A rated duration of phase-to-earth short-circuit (t_{ke}) shall also be assigned to the assembly for the parts of the earthing circuit connecting each phase of the main circuit to the earthing point

provided or, where applicable, connecting the short-circuiting point between phases to the earthing point provided. This value may be lower than that of the main circuit.

5.9 Rated supply voltage of auxiliary and control circuits (U_a)

Subclause 5.9 of IEC 62271-1:2017 is applicable.

5.10 Rated supply frequency of auxiliary and control circuits

Subclause 5.10 of IEC 62271-1:2017 is applicable.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.11 of IEC 62271-1:2017 is applicable.

5.101 Classification of earthing function through main switching device

When the earthing function is performed by the main switching device in combination with a class E0 earthing switch, class E1 or E2, as defined in IEC 62271-102:2018, may be assigned to that earthing function.

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

5.102 Rated cable test voltages ($U_{ct\ (AC)}$, $U_{ct\ (DC)}$)

5.102.1 General

If the assembly is designed to allow for dielectric testing of connected high-voltage cables while the busbar(s) of the associated functional unit remain in service, one or more rated cable test voltages shall be assigned.

5.102.2 Rated power-frequency cable test voltage $U_{ct\ (AC)}$

The rated power-frequency cable test voltage is the maximum AC test voltage with a duration of 1 min. that may be applied to cables when connected to the assembly, which may be in service.

5.102.3 Rated DC cable test voltage $U_{ct\ (DC)}$ with rated duration $t_{ct\ (DC)}$

The rated DC cable test voltage is the maximum DC test voltage that may be applied to cables when connected to the assembly, which may be in service.

A rated DC cable test voltage is considered covering very low frequency testing (e.g. 0,1 Hz) with peak value up to the rated DC value for the same rated duration.

If no rated duration $t_{ct\ (DC)}$ is specified, then by default this duration is 15 min.

NOTE Guidance can be found in IEEE 400.2 [3].

5.103 Ratings of the internal arc classification (IAC)

5.103.1 General

If an IAC classification is assigned by the manufacturer, several ratings shall be specified. These ratings shall be indicated by means of a designation as follows:

– Classification: IAC (Internal Arc Classification);

– Type of accessibility: A, B;
– Classified sides of the enclosure: F, L, R;
– Rated three-phase arc fault values: current I_A [kA] and duration t_A [s];
– Rated single-phase arc fault values (where applicable): current I_{Ae} [kA] and duration t_{Ae} [s].

5.103.2 Types of accessibility

Two types of accessibility to the enclosure of an assembly at the site of installation are defined:

– Accessibility Type A: restricted to authorized personnel only;
– Accessibility Type B: unrestricted accessibility, including that of the general public.

NOTE 1 For pole-mounted switchgear and controlgear, refer to IEC 62271-214 [4].

NOTE 2 IAC classification as defined in this document does not apply to opened compartments and to arc protection between compartments, except if opening is necessary to perform switching operations. IEEE C37.20.7 defines Suffix B designation for opened low-voltage compartments and Suffix C designation for arc protection between compartments [5].

5.103.3 Classified sides

In case of IAC, at least the front side of the assembly shall be classified for at least accessibility type A, by the manufacturer. The sides of the assembly 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.

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

The value of rated arc fault currents should be selected from the R10 series specified in IEC 60059 [6].

Two ratings of the arc fault currents are recognized:

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

The manufacturer shall specify the compartments to which the single-phase-to-earth arc fault current rating is applicable. Such value may be assigned to an assembly where its construction will prevent the arc from becoming multiphase, as demonstrated during the internal arc test.

In the case where all high-voltage compartments are only designed for single-phase-to-earth arc faults, instead of I_A, the I_{Ae} rating shall be assigned.

NOTE Information about the relationship between the type of network neutral earthing and the single-phase-to-earth arc fault current is provided in 9.103.6.

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

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

If applicable, the rated duration (t_{Ae}) of the single-phase-to-earth arc fault shall be assigned 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.

6 Design and construction

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC 62271-1:2017 is applicable.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC 62271-1:2017 is applicable

NOTE For the handling of SF_6 and its mixtures refer to IEC 62271-4 [7].

6.3 Earthing of switchgear and controlgear

Subclause 6.3 of IEC 62271-1:2017 is applicable with the following additions:

6.3.101 Earthing of the high-voltage conductive parts

All high-voltage conductive parts to which access is provided with the assembly in service, shall have the possibility of being earthed prior to becoming accessible. This is not applicable to removable parts which become accessible after being separated from the assembly and to withdrawable parts in test position or in disconnected position (refer to 6.101).

Where earthing connections shall be able 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.

The connection from the short-circuiting point between phases to the earthing circuit may be dimensioned to the specifications of the earthing circuit.

6.3.102 Earthing of enclosure(s)

Metal enclosure(s) shall be electrically connected (directly or indirectly) to the earthing point provided. Small parts fixed to metal enclosure(s), up to a maximum of 12,5 mm in diameter, for example screw heads, need not be electrically connected to the earthing point provided. All the metallic parts intended to be earthed and not belonging to a high-voltage or auxiliary circuit shall also be electrically connected to the earthing point provided.

The interconnections within each functional unit shall be made by adequate means (e.g. fastening by bolting or welding), providing electrical continuity between the frame, covers, doors, metal partitions or other structural parts to the earthing point. Doors of the high-voltage compartments shall be electrically connected to the frame by adequate means.

NOTE 1 Enclosure and doors are considered in 6.102.

NOTE 2 EMC demands for the complete installation can require a special approach of the earthing circuit of the assembly.

6.3.103 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 provide a current-carrying capability not less than that required for enclosures (refer to 6.102.1).

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.

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 (refer to 5.6, 5.7 and 5.8).

6.3.104 Earthing circuit

The parts of the earthing circuit of the assembly connecting each functional unit to the earthing point shall be capable of carrying the rated short-time and peak phase-to-earth withstand current (I_{ke}, I_{pe}) and duration (t_{ke}).

NOTE 1 It is assumed that the short-circuiting point between phases of the earthing circuit is within each functional unit.

For transport units to be assembled during final installation, the resulting earthing circuit shall be capable of carrying its rated short-time and peak withstand currents and duration.

Parts of metal enclosures may form part of the earthing circuit.

If a dedicated earthing conductor is applied as earthing circuit of the assembly, its cross-section shall be not less than 30 mm^2.

NOTE 2 If the earthing circuit consists of an earthing copper conductor extending the whole length of the assembly, for the rated short-time withstand current, a current density in the earthing conductor, not exceeding 200 A/mm^2 for a rated duration of 1 s or 125 A/mm^2 for a rated duration of 3 s is generally sufficient.

NOTE 3 A method of calculating cross-sectional areas of conductors is given in IEC 60724 [8].

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 9.102.

6.4 Auxiliary and control equipment and circuits

Subclause 6.4 of IEC 62271-1:2017 is applicable.

6.5 Dependent power operation

Subclause 6.5 of IEC 62271-1:2017 is applicable.

6.6 Stored energy operation

Subclause 6.6 of IEC 62271-1:2017 is applicable.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC 62271-1:2017 is applicable.

6.8 Manually operated actuators

Subclause 6.8 of IEC 62271-1:2017 is applicable.

6.9 Operation of releases

Subclause 6.9 of IEC 62271-1:2017 is applicable.

6.10 Pressure/level indication

Subclause 6.10 of IEC 62271-1:2017 is applicable with the following addition to 6.10.1 of IEC 62271-1:2017.

For gas-filled compartments where the minimum functional pressure exceeds 200 kPa (absolute pressure at 20 °C) an indication shall be provided when the absolute pressure at 20 °C has fallen below the minimum functional level (refer to 3.6.114).

NOTE 1 The indication might include monitoring of pressure (density).

Closed pressure systems with minimum functional pressure above 200 kPa (absolute pressure) shall have a defined alarm pressure (density) level.

NOTE 2 Alarm pressure (density) is defined in IEC 62271-1:2017, 3.6.5.3 and 3.6.5.4.

An example of pressure coordination chart is shown in Figure E.1.

6.11 Nameplates

Subclause 6.11 of IEC 62271-1:2017 is applicable, except for Table 9, with the following additions:

Assemblies 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	Marking (**)	Condition: Marking only required if
(1)[a,b]	(2)[a]	(3)	(4)	(5)
Name of manufacturer			X	
Manufacturer's type designation			X	
Serial number			X	
Manufacturer's instructions 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	$U_{ct\ (AC)}$	kV	(X)	
Rated DC cable test voltage	$U_{ct\ (DC)}$	kV	(X)	
Rated duration for DC cable test	$t_{ct\ (DC)}$	min	(X)	
Rated continuous current	I_r	A	X	
Rated short-time withstand current	I_k	kA	X	
Rated peak withstand current	I_p	kA	X	
Rated duration of short-circuit	t_k	s	X	
Rated short-time phase-to-earth withstand current	I_{ke}	kA	Y	different from I_k (main circuit)

	Abbreviation	Unit	Marking (**)	Condition: Marking only required if
(1)[a,b]	(2)[a]	(3)	(4)	(5)
Rated peak phase-to-earth withstand current	I_{pe}	kA	Y	different from I_p
Rated duration of phase-to-earth short-circuit	t_{ke}	s	Y	different from t_k (main circuit)
Filling level for insulation and/or switching (*)	p_{re}, ρ_{re}, m_{re}	kPa, kg/m^3 or kg	(X)	
Alarm level for insulation and/or switching (*)	p_{ae}, ρ_{ae}, m_{ae}	kPa, kg/m^3 or kg	Y	closed pressure system with minimum functional pressure above 200 kPa (abs.)
Minimum functional level for insulation and/or switching (*)	p_{me}, ρ_{me}, m_{me}	kPa, kg/m^3 or kg	(X)	
Filling level for operation (*)	p_{rm}, ρ_{rm}, m_{rm}	kPa, kg/m^3 or kg	(X)	
Alarm level for operation (*)	p_{am}, ρ_{am}, m_{am}	kPa, kg/m^3 or kg	Y	closed pressure system with minimum functional pressure above 200 kPa (abs.)
Minimum functional level for operation (*)	p_{mm}, ρ_{mm}, m_{mm}	kPa, kg/m^3 or kg	(X)	
Loss of service continuity category	LSC		(X)	
Internal arc classification	IAC		(X)	
Type of accessibility	A or B		(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	(X)	
Rated supply voltage(s) of auxiliary and control circuits. Specify DC/AC (with rated frequency)	U_a	V	(X)	
Type and mass of fluid (liquid or gas) for insulation	M_f	kg	(X)	
Mass of the assembly (including any fluid)	M	kg	Y	more than 300 kg
Minimum and maximum ambient air temperature		°C	Y	different from – 5 °C and/or 40 °C

(*) Density or absolute pressure (abs.) or relative pressure (rel.) to be stated at 20°C for gases, and mass for liquids

(**) X = the marking of these values is mandatory;
(X) = the marking of these values is where applicable;
Y = conditions for marking of these values are given in column (5).

[a] The abbreviation in column (2) can be used instead of the terms in column (1).

[b] When terms in column (1) are used, the word "rated" need not appear.

The information according to Table 1, of the complete assembly, shall be legible during normal service. If applicable, one common nameplate for the complete assembly 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 be legible during normal service.

The removable parts, if any, shall have a separate nameplate which, if applicable, may contain data relating to the functional unit(s) they are designed for. These nameplates need only be legible when the removable part is in the removed position.

NOTE Fuses are removable devices that do not require such specific information because they respond to standardized dimensions.

6.12 Locking devices

Subclause 6.12 of IEC 62271-1:2017 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 7.102.2. The following provisions are defined for switching devices of main and earthing circuits.

a) For removable parts of assemblies

- the withdrawal or engagement of any switching device shall be prevented unless it is in the open position;
- the operation of any switching device shall be prevented unless it is only in the service, disconnected, removed or test position;
- the interlock shall prevent the closing of any switching device 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) For other parts of assemblies

- interlocks shall be provided to prevent operation of disconnectors under conditions other than those for which they are intended (refer to IEC 62271-102:2018). The operation of a disconnector shall be prevented unless the circuit is open. The following are exempt:
  - switch-disconnector;
  - double busbar system designed to have a busbar transfer without current interruption.
- the operation of the circuit-breaker, switch or contactor shall be prevented by interlocks as long as the associated switching devices, i.e. disconnector and/or earthing switch, have not reached their dedicated closed or open position;
- if earthing of a circuit is provided by the main switching device (circuit-breaker, switch or contactor) in series with an earthing switch (or any earthing device), 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/or blocking of the mechanical trip;
- 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 switching devices.

Regarding removable fuse-links, their withdrawal or engagement shall be prevented unless the fuse-base contacts are earthed or isolated from all sources of supply; see also 6.101.

The manufacturer shall give all necessary information on the character and function of interlocks.

NOTE For interlocks with covers and doors, refer to 6.102.2.

If electrical 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 a case, the manufacturer shall clearly identify this facility and define the procedures for operation.

6.13 Position indication

Subclause 6.13 of IEC 62271-1:2017 is applicable. In addition, for all devices involved in disconnecting and earthing functions, 6.104.3 of IEC 62271-102:2018 is applicable.

6.14 Degrees of protection provided by enclosures

6.14.1 General

Subclauses 6.14.1, of IEC 62271-1:2017 is applicable.

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

Subclause 6.14.2 of IEC 62271-1:2017 is not applicable. The minimum degree of protection shall be IP2X, according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

Additional requirements are specified in 6.102 and 6.103.

6.14.3 Protection against ingress of water (IP coding)

Subclause 6.14.3 of IEC 62271-1:2017 is applicable.

6.14.4 Protection of equipment against mechanical impact under normal operating conditions (IK coding)

Subclause 6.14.4 of IEC 62271-1:2017 is applicable with the following addition:

For indoor installation, the minimum impact level shall be IK07 according to IEC 62262 (2 J).

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC 62271-1:2017 is not applicable.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is applicable with the following addition:

Additional requirements are specified in 6.103.2.3.

6.17 Tightness for liquid systems

Subclause 6.17 of IEC 62271-1:2017 is applicable with the following addition:

Additional requirements are specified in 6.103.2.3.

6.18 Fire hazard (flammability)

Subclause 6.18 of IEC 62271-1:2017 is applicable.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC 62271-1:2017 is applicable.

6.20 X-ray emission

Subclause 6.20 of IEC 62271-1:2017 is applicable.

6.21 Corrosion

Subclause 6.21 of IEC 62271-1:2017 is applicable.

6.22 Filling levels for insulation, switching and/or operation

Subclause 6.22 of IEC 62271-1:2017 is applicable.

6.101 General requirements for assemblies

Assemblies shall be designed so that the operations in normal use can be carried out safely. Examples of operations a manufacturer can define as normal use are:

– determination of the presence or absence of voltage related to "in service conditions" on the main circuit including the checking of phase sequence, refer to IEC 62271-213:2021 and IEC 62271-215:2021;
– earthing of connected cables, locating of cable faults, voltage tests on connected cables;
– the elimination of dangerous trapped electrostatic charges.

In the case where a high-voltage compartment may be opened, i.e. accessible compartment, safe operation of the assembly requires (irrespective of whether of fixed or withdrawable pattern) that the high-voltage parts are isolated from all sources of supply and earthed. Exempted from this requirement are:

– high-voltage parts that are moved to the disconnected position with corresponding shutters closed;
– high-voltage parts, if embedded by solid-insulation material and complying with at least protection category PA of IEC 62271-201:2014.

Disconnecting devices used for isolation shall be secured against re-connection.

If a withdrawable or removable part does not include an earthing device that is intended to earth the main circuit of that removable part before becoming accessible, it shall be possible, by manual earthing means, to safely discharge trapped charges from that removable part. The manufacturer shall define the recommended procedure in the manufacturer's instructions reference.

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 interchange ability. 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 that the functional unit is capable of operation at the increased ratings of the removable part or component.

Components contained in an assembly shall be in accordance with their various relevant standards. This document supplements or even replaces the standards for the individual components regarding their installation in assemblies.

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

6.102 Metal enclosure

6.102.1 General

The walls of a room shall not be considered as parts of the enclosure. The floor surface below the installed assembly 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.

The enclosure shall be metal. The following exceptions apply:

– parts of the enclosure may be of non-metal material, provided that all high-voltage parts are completely enclosed by metal partitions or shutters that are connected to the earthing circuit;

– inspection windows complying with 6.102.4;

– the floor surface below the installed assembly provided that it is solid and does not allow access underneath the assembly.

When the assembly is installed, the enclosure shall provide at least the degree of protection IP2X, according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013. The specified degree of protection shall be provided by the enclosure with all the doors and covers closed as under normal operating conditions, irrespective of how these doors and covers are held in position.

Enclosures shall also ensure protection in accordance with the following conditions:

– Metal parts of the enclosures shall be designed to carry 30 A (DC) with a voltage drop of maximum 3 V to the earthing point provided.

– Parts of the enclosure enclosing tool-based accessible high-voltage compartments shall be provided with a clear labelling of the electrical risk if removed or opened.

– 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 assembly during operation or maintenance, the design shall be such that the relevant areas will support the weight of the operator. In such a case, the IP degree shall not be affected as well as no permanent deformation is allowed and the areas on the equipment where it is not safe to stand or walk, for example pressure relief flaps, shall be clearly identified.

6.102.2 Covers and doors

Covers and doors that are part of the enclosure shall be made of metal. However, covers and doors may be made of insulating material, provided that high-voltage parts are enclosed by metal partitions or shutters connected to the earthing point provided.

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

Covers and doors shall not be made of woven wire mesh, expanded metal or similar. When ventilating openings, vent outlets or inspection windows are incorporated in the cover or door, reference is made to 6.102.4 or to 6.102.5.

Covers and 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 and doors are recognized with regard to the type of high-voltage accessible compartments they provide access to:

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

These covers and doors (fixed covers) need not be opened for normal use as stated by the manufacturer. It shall not be possible for them to be opened, dismantled or removed without the use of tools. Special procedures are required to safeguard that opening can only be realized if precautions to ensure electrical safety have been taken.

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

These covers and doors shall be provided if there is a need to access the compartment for normal use as stated by the manufacturer. These covers and doors shall not require tools for their opening or removal. It is permissible that the manipulation of some fixing elements for their opening or removal is required, and they shall have the following features:

– interlock controlled accessible compartments shall be provided with interlocking devices so that opening of the compartment shall only be possible when the high-voltage parts contained in the compartment being made accessible are isolated and earthed, or are in the disconnected position with corresponding shutters closed;

– procedure-based accessible compartments shall be provided with provision for locking, e.g. padlocking. Suitable procedures should be put in place by the user to ensure that a procedure-based accessible compartment is opened only when the high-voltage parts contained in the compartment being made accessible are isolated and earthed, or in the disconnected position with corresponding shutters closed. Procedures can be dictated by the legislation of the country of installation or by the user's safety documentation.

NOTE Examples of fixing elements are screws, bolts, nuts, turning fasteners and sliding fasteners.

If interlock-controlled or procedure-based accessible compartments have covers that can be opened by tools, other than those that are interlocked or locked, proper procedures or specific warning labels should be applied.

Access to a closed interlock-controlled or procedure-based compartment through covers needing only the use of tools to be opened or removed is not intended for normal use. Once an interlocked or locked door or cover of an accessible compartment is opened or removed for normal use, it is permissible that the opening or removing of other covers of the same accessible compartment requires the use of tools.

6.102.3 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 3.6.110 to 3.6.112, they shall be metal, earthed and provide as minimum degree of protection IP2X.

In this respect it should be noted that:

– a partition or shutter becomes a part of the enclosure if it is accessible in any of the positions defined in 3.6.110 to 3.6.112 and if no door is provided which can be closed in the positions defined in 3.6.109 to 3.6.112;

– if a door is provided which can be closed in the positions defined in 3.6.109 to 3.6.112, the partition or shutter behind the door is not considered to be a part of the enclosure.

6.102.4 Inspection windows

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

They shall be covered by a transparent sheet of mechanical strength comparable to that of the enclosure. Precautions shall be taken to prevent the formation of dangerous electrostatic charges, either by clearance or by electrostatic shielding (e.g. a suitable earthed wire-mesh on the inside of the window).

The insulation between high-voltage live parts and the accessible surface of the inspection windows shall comply with the rated insulation levels U_d and U_p according to 5.3.

6.102.5 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 enclosure is obtained. Such openings may make use of wire mesh or the like provided that it is of suitable mechanical strength.

6.103 High-voltage compartments

6.103.1 General

High-voltage compartments may be of various types, for example:

– air insulated;
– liquid-filled (see 6.103.2);
– gas-filled (see 6.103.2).

High-voltage compartments should also be classified as accessible or non-accessible.

NOTE 1 Only interlock-controlled accessible compartments and procedure based accessible compartments are considered when defining the LSC category of a functional unit.

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.

Electrical connections between the main circuit of the assembly and the external conductors (cables or bars) to the electrical network or high-voltage apparatus of the installation shall be made within a high-voltage accessible compartment. This compartment shall be designated as a "connection compartment".

Where other main components (e.g. circuit-breakers, busbars) are contained in the connection compartment, then the designation should primarily remain as the connection compartment.

The connection compartment may be further identified according to the several components enclosed, for example connection/CT, or connection/circuit-breaker compartment. However, for the purposes of LSC categorization, the designation is "connection compartment".

The LSC category can only be assigned to functional units that include a connection compartment. This implies that e.g. a bus-sectionaliser or bus-coupler functional unit will have no LSC category, refer to Figure 8 and Figure 9.

Busbar compartments may extend through several functional units without the need for bushings or other equivalent means. However, in the case of LSC2, LSC2A, LSC2B assemblies with accessible busbar compartments (refer to 9.101.3), separate compartments shall be provided for each set of busbars, for example in double busbar systems and for sections of switchable or disconnectable busbars.

NOTE 2 The busbar system is not considered as a functional unit.

Parts of the busbar systems, in between two high-voltage compartments of functional units, shall be considered as part of their adjacent compartments if IP2X is ensured for these "in between" parts by the enclosures of both adjacent high-voltage compartments. In case IP2X is not met, a separate compartment shall be defined for these "in-between" parts.

Parts of the busbar at the end of the busbar system shall be considered as part of the adjacent compartment if their length out of the enclosure of the high-voltage compartment is less than 12,5 mm. If this criterion is not met, a separate compartment shall be defined for these busbar extension elements.

6.103.2 Fluid-filled compartments (gas or liquid)

6.103.2.1 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 such that gas-filled compartments are filled with a gas that is stable and non-corrosive in the conditions that prevail inside the compartment; since measures to maintain the gas in this condition with only small fluctuations in pressure are fundamental to the operation of the assembly 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.

NOTE 1 The non-corrosive conditions that prevail inside gas-filled compartments are maintained by appropriate measures such as filter material to adsorb humidity and decomposition products, if any.

Materials used in the construction of enclosures should be of known and certified minimum physical properties on which pressure tests are based (see 7.103). The manufacturer is responsible for the selection of the materials and the maintenance of these minimum properties, based on certification of the material supplier or tests conducted by the manufacturer, or both.

NOTE 2 See also Annex C.

6.103.2.2 Design

The design of a fluid-filled compartment shall be based on the nature of the fluid, the design temperature and the design pressure as defined in this document.

For indoor installations, 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 continuous current. For outdoor installations, other possible influences, for example solar radiation, shall be taken into account.

The design pressure of a compartment is equal to the maximum pressure difference between the fluid inside the compartment at design temperature that the fluid used for insulation can reach under specified maximum service conditions, and the surrounding media, like ambient air or insulation fluids in other compartments.

Therefore, the design pressure calculation shall also consider:

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.

The design of the fluid-filled compartment shall also take into account the possibility of the occurrence of an internal arc fault.

In normal service, the pressure inside a gas-filled compartment varies from the filling pressure p_{re} with the gas temperature variations, at different service conditions, and possible leaks. Several pressure values shall be coordinated when designing a fluid-filled compartment. An example is shown in Figure E.1.

6.103.2.3 Tightness

The manufacturer shall state the pressure system used and the permissible leakage rate for the fluid-filled compartments (refer to 6.16 and 6.17 of IEC 62271-1:2017). This shall take into

account the relative limits fixed in Table 15 of IEC 62271-1:2017 for temporarily increased leakage rates at temperatures other than 20 ºC.

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.

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

6.103.2.4 Pressure relief of fluid-filled compartments

Where pressure-relief devices or designs are provided, they shall be orientated so as to minimize the danger to an operator during the time that he is performing his normal operating duties if gases or vapours are escaping under pressure. Pressure relief devices shall operate with relative pressure above 1,3 times the design pressure. The pressure relief device may be a designed, deliberate weak area of the compartment or a dedicated device, for example a bursting disc.

6.103.3 Partitions and shutters

6.103.3.1 General

A compartment can contain barriers, structures or components that are designed to provide various functions, such as mechanical or dielectrical integrity, but not designed to function as a partition or enclosure.

Partitions and shutters, when accessible in service, shall provide at least the degree of protection IP2X according to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

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

Openings in the enclosure of an assembly and in the partitions between compartments accessible during service through which contacts of removable or withdrawable parts engage fixed contacts, shall be provided with automatic shutters to ensure the protection of persons in any of the positions defined in 3.6.110 to 3.6.112. 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 high-voltage compartment, (e.g. connection compartment is opened, but shutters are located in circuit-breaker compartment). In such situations, verification of the shutter status may require access to the second compartment or provision of an inspection window or reliable indicating device.

If one or more set(s) of fixed contacts can be made accessible through opened shutters (e.g. for maintenance or test purposes), then the shutters shall be provided with means of locking each set independently in the closed position.

If the automatic closing of shutters can be made inoperative in order to retain them in the open position (e.g. for maintenance or test purposes), then it shall not be possible either for the switching device to return to the service position or to close the switching device in the service position, until the automatic operation of the shutters is restored. This can be realized for example by preventing the switching device to return to its service position or by automatic restoration when 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 11.5). Insertion of such a temporary partition shall be possible before the compartment to be opened exposes the high-voltage parts that are intended to be kept energized.

For class PM, partitions and shutters between opened compartments and remaining high-voltage live parts of the assembly shall be metal; otherwise, the class is PI (refer to 3.6.106 to 3.6.108).

6.103.3.2 Metal partitions and shutters

Metal partitions and shutters or metallic parts of them shall be connected to the earthing point provided with a voltage drop of less than 3 V at 30 A (DC).

Discontinuity in the metal partitions and closed metal shutters which may become accessible shall be less than 12,5 mm.

NOTE The word "discontinuity" covers any insulating or non-earthed area, or path, through the partition.

6.103.3.3 Non-metal partitions and shutters

Non-metal partitions and shutters, made or partly made of insulating material, which may become accessible shall meet the following requirements:

a) the insulation between high-voltage live parts and the accessible surface of insulating partitions and shutters shall withstand the test voltages specified in 5.3 of IEC 62271-1:2017 for voltage tests to earth and between poles;

b) the insulating material shall withstand the power-frequency test voltage specified in item a). The appropriate test methods given in IEC 60243-1 [9] should be applied;

c) the insulation between high-voltage live parts and the inner surface of insulating partitions and shutters facing these shall withstand at least 150 % of the rated voltage of the equipment if a separate insulating medium, i.e. gas or liquid, is in-between;

NOTE Solid-insulation embedding high-voltage conducting parts is not considered as a partition.

d) if a leakage current can reach the accessible side of the 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 7.104.3).

6.104 Removable parts

If the assembly incorporates removable parts which may be exchanged, for example fuse-links, then the manufacturer shall provide a reference list.

NOTE 1 For a reference list of fuse-links of switch-fuse combinations, IEC 62271-105 provides further information.

Removable parts for ensuring the isolating distance between the high-voltage conductors shall comply with IEC 62271-102:2018, except for mechanical operation tests (refer to 7.102 and 8.102). 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 62271-102:2018.

Removable parts that are fixed, for example by bolts and/or screws, are not subject to mechanical operation tests according to 7.102.1, if not otherwise specified by the manufacturer.

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

– the isolating distance is visible with the removable part removed;

– in case of a withdrawable part:

  • 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 2 Refer to IEC 62271-102:2018 and also to Annex C.

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 assemblies, the transfer of withdrawable parts to or from 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.

6.105 Provisions for dielectric tests on cables

Assemblies may be designed to allow the testing of cables while they are connected to the assembly. This may be performed either from a dedicated test connection, or from the cable terminations. In both cases the assembly shall have rated cable test voltage(s) as specified in 5.102 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.

6.106 Internal arc fault

Assemblies that satisfy the requirements of this document are designed and manufactured, in principle, to prevent the occurrence of internal arc faults. However, where internal arc classification IAC is assigned, the assembly shall be designed to give a defined level of protection of persons in the event of an internal arc, when the assembly is in normal operating conditions.

Normal operating conditions imply that doors and covers are closed unless opening is necessary to perform switching operations.

If IAC is assigned, then this designation shall be included in the nameplate (refer to 6.11).

Some examples for designations of the IAC classification are given in 9.103.6.

7 Type tests

7.1 General

7.1.1 Basics

Subclause 7.1.1 of IEC 62271-1:2017 is applicable with the following addition:

Components contained in an assembly shall comply with their individual component standards, taking into account Clause 7.

Because of the variety of types, ratings and possible combinations of components, it is not practicable to make type tests with all the arrangements of an assembly. The validity of type tests performed on one test object with a defined set of ratings to other assemblies of the same family with a different set of ratings or different arrangements of components may be evaluated; in that case IEC TR 62271-307 [10] should be applied.

The type tests and verifications comprise:

Mandatory type tests to verify the:

a) rated insulation level of the equipment (see 7.2);
b) measurement of the resistance of circuits (see 7.4);
c) rated continuous current of any part of the equipment and measurement of the resistance of circuits (see 7.5);
d) capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents (see 7.6);
e) making and breaking capacity of the included switching devices (see 7.101);
f) mechanical operation of the included switching devices and removable parts (see 7.102);
g) IP protection code (see 7.7.1);
h) IK protection code (see 7.7.2).

Mandatory type tests, where applicable, to verify the:

i) auxiliary and control circuits (see 7.10);
j) protection of persons against dangerous electrical effects (see 7.104);
k) pressure withstand of gas-filled compartments (see 7.103);
l) tightness of gas- or liquid-filled compartments (see 7.8);
m) IAC classification (see 7.105);
n) electromagnetic compatibility (EMC) (see 7.9);
o) X-radiation level for vacuum interrupters (see 7.11);
p) protection of the equipment against external effects due to weather (see 7.7.1);
q) rated cable test voltages (see 7.2.101).

Optional type tests (subject to agreement between manufacturer and user):

r) tests to evaluate the insulation of the equipment by the measurement of partial discharges (see 7.2.10).

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

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC 62271-1:2017 is applicable.

7.1.3 Information to be included in type-test reports

Subclause 7.1.3 of IEC 62271-1:2017 is applicable with the following addition:

For the test report regarding continuous current tests, refer also to 7.5.101.

For the report regarding internal arc tests, refer to 7.105.6.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2.1 of IEC 62271-1:2017 is applicable.

7.2.2 Ambient air conditions during tests

Subclause 7.2.2 of IEC 62271-1:2017 is applicable.

7.2.3 Wet test procedure

Subclause 7.2.3 of IEC 62271-1:2017 is not applicable.

7.2.4 Arrangement of the equipment

Subclause 7.2.4 of IEC 62271-1:2017 is applicable with the following addition:

Overvoltage protective devices shall be disconnected or removed for the test.

For assemblies using fluid (liquid or gas) for insulation, dielectric tests shall be performed on the test objects filled with the insulating fluid specified by the manufacturer, to the minimum functional level also specified by the manufacturer.

7.2.5 Criteria to pass the test

Subclause 7.2.5 of IEC 62271-1:2017 is applicable with the following modifications:

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

For fluid-filled compartments tested with test bushings that are not part of the assembly, impulses resulting in flashover along the surface of the test bushings are not considered as part of the test series.

7.2.6 Application of the test voltage and test conditions

Subclause 7.2.6 of IEC 62271-1:2017 is applicable with the exception of 7.2.6.2 and with the following additions:

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, they shall cover the following tests:

a) To earth and between phases

The test voltages specified in 7.2.7 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 or the frame and to the earth terminal of the test supply.

If the phase conductors are segregated, only tests to earth shall apply.

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 or test position may result in less favourable field conditions. Under such conditions the tests shall be repeated with such device(s) in those specific positions. However, switching devices do not need to be tested in open position when their component standard does not require to test them in this open position, and removable parts themselves shall not be subjected to these voltage tests whilst they are in the disconnected, test or removed position. The earthing of removable parts in these positions during the tests shall be as in service.

In case specific devices, such as current transformers, cable terminations or overcurrent releases/indicators, could influence the electrical fields, they shall be installed as in service during these tests. For impulse voltage tests, the arrangements according to 7.2.7.3 are allowed. In case of doubt about the most unfavourable arrangement, tests shall be repeated with alternative configurations.

In order to check compliance with the requirements of 6.102.4 and item a) of 6.103.3.3, inspection windows, partitions and shutters of insulating material shall be covered on the side accessible during operation or maintenance, in the most unfavourable situation for the test, with a circular or square metal foil having an area as large as possible but not exceeding 100 cm^2 which shall be connected to earth. In case of doubt about the most unfavourable situation, the tests shall be repeated with different situations. For convenience of testing, subject to agreement between testing station and manufacturer, more than one metal foil may be applied simultaneously, or larger parts of the insulating material may be covered.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in 7.2.7 according to the test procedures as stated in 7.2.6.3 of IEC 62271-1:2017.

The isolating distance could be formed by:

– a disconnector in the open position;

– the distance between the two parts of the main circuit intended to be connected by a withdrawable or removable switching device;

– the sum of the clearances between several open gaps in series.

If, in the disconnected or test position, an earthed metal shutter is interposed between the disengaged contacts to ensure a segregation, the gap between the earthed metal shutter and the live parts shall withstand only the test voltages required to earth according to item a) above.

If there is no segregation between the fixed part and the withdrawable part when an isolating distance is established, the test voltages specified across the isolating distance shall be applied under the following conditions: 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.

c) Complementary tests

In order to check compliance with the requirement of item c) of 6.103.3.3, if applicable, the insulation between the high-voltage live parts and the inside of insulating partitions or shutters shall be subjected to a power-frequency test voltage of 150 % of the rated voltage U_r for 1 min. after covering the inner surface of the partition or shutter facing the live parts by an earthed metal foil as described under a) above.

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

7.2.7.1 General

Subclause 7.2.7.1 of IEC 62271-1:2017 is applicable.

7.2.7.2 Power-frequency voltage tests

Subclause 7.2.7.2 of IEC 62271-1:2017 is replaced by the following provisions:

Assemblies 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. A transformer, a coil, or a similar device normally connected between phases shall be disconnected from the pole stressed with test voltage.

At common value power-frequency voltage tests, one terminal of the test transformer shall be connected to earth and to the enclosure of the assembly.

For isolating distance power-frequency voltage tests, 7.2.6.3 of IEC 62271-1:2017, is applicable, with "frame" to be replaced by "enclosure".

For the special cases considered in 7.2.6.3 of IEC 62271-1:2017, the isolating distance may be tested as follows:

– Preferred method: In this case, neither of the two voltage values applied to the two terminals shall be higher than the rated withstand voltage phase-to-earth;
– Alternative method: The voltage to earth of the frame U_f does not need to be bonded so accurately and the frame may even be insulated from earth.

7.2.7.3 Lightning impulse voltage tests

Subclause 7.2.7.3 of IEC 62271-1:2017 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.

Current transformer secondary windings shall be short-circuited and earthed. Current transformers may have their primaries short-circuited too.

For common value lightning impulse voltage tests, one terminal of the impulse generator shall be connected to earth and to the enclosure of the assembly.

For isolating distance lightning impulse voltage tests, 7.2.6.3 of IEC 62271-1:2017, is applicable with "frame" to be replaced by "enclosure".

7.2.8 Tests of switchgear and controlgear of U_r > 245 kV

Subclause 7.2.8 of IEC 62271-1:2017 is not applicable.

7.2.9 Artificial pollution tests for outdoor insulators

Subclause 7.2.9 of IEC 62271-1:2017 is not applicable.

7.2.10 Partial discharge tests

Subclause 7.2.10 of IEC 62271-1:2017 is applicable with the following additions:

If the test is performed, it shall be according to Annex B.

NOTE It is good engineering practice to carry out a partial discharge type test on a complete functional unit or assembly (where possible).

7.2.11 Dielectric tests on auxiliary and control circuits

Subclause 7.2.11 of IEC 62271-1:2017 is applicable with the following additions:

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

Voltage-limiting devices in the auxiliary and control circuits, if any, shall be disconnected.

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

7.2.12 Voltage test as condition check

Subclause 7.2.12 of IEC 62271-1:2017 is applicable.

7.2.101 Dielectric tests on cable testing circuits

This type test is applicable only to assemblies having one or more rated cable test voltage(s).

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

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

The test voltages defined under a) and b) shall be applied simultaneously. If, during this test, there is segregation between the cable test connections and the busbars, the test voltage on the busbar side may be omitted.

For AC test voltages, the two test voltages shall be in phase opposition.

For AC cable test voltages $U_{ct\ (AC)}$ the duration of the test shall be 1 min. For DC cable test voltages $U_{ct\ (DC)}$, its rated duration shall be kept for each polarity (refer to 5.102.3).

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2017 is not applicable.

7.4 Resistance measurement

7.4.1 Measurement of the resistance of auxiliary contacts class 1 and class 2

Subclause 7.4.1 of IEC 62271-1:2017 is applicable.

7.4.2 Measurement of the resistance of auxiliary contacts class 3

Subclause 7.4.2 of IEC 62271-1:2017 is applicable.

7.4.3 Electrical continuity of earthed metallic parts test

Subclause 7.4.3 of IEC 62271-1:2017 is applicable.

7.4.4 Resistance measurement of contacts and connections in the main circuit as a condition check

Subclause 7.4.4 of IEC 62271-1:2017 is applicable with the following addition:

The maximum acceptable increase of resistance for individual switching devices within the assembly after mechanical and/or making and breaking tests is defined in the corresponding switching device standard of the IEC 62271 series.

7.5 Continuous current tests

7.5.1 Condition of the test object

Subclause 7.5.1 of IEC 62271-1:2017 is applicable.

7.5.2 Arrangement of the equipment

Subclause 7.5.2 of IEC 62271-1:2017 is applicable with the following modifications:

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.

In case of functional unit(s) incorporating fuses, the test shall be performed with the fuse-links generating the highest power dissipation from the reference list provided by the assembly manufacturer.

7.5.3 Test current and duration

7.5.3.1 Test on main circuit

Subclause 7.5.3.1 of IEC 62271-1:2017 is applicable with the following modifications:

Each functional unit of the assembly shall be tested once at its rated continuous current, with the adjacent functional units (if any) at the maximum continuous current that the electrical scheme of the assembly and the rated continuous current of each functional unit allows. Alternatively, each functional unit may be individually tested for its rated continuous current with either heat insulation or heaters at the sides reproducing the same conditions as with the preceding testing procedure.

When testing with the fuse-links generating the highest power dissipation, the continuous current indicated on the list of fuse-links provided by the assembly manufacturer shall be applied.

7.5.3.2 Test of the auxiliary and control equipment

Subclause 7.5.3.2 of IEC 62271-1:2017 is applicable with the following exception:

This test need not be performed on circuits and components of auxiliary and control equipment which already have demonstrated their operation at ambient temperature limits during mechanical tests with the high-voltage switching devices installed inside the assembly, according to the relevant component standard, for example IEC 62271-100, IEC 62271-102 or IEC 62271-103.

7.5.4 Temperature measurement during test

Subclause 7.5.4 of IEC 62271-1:2017 is applicable with the following modifications to 7.5.4.2:

The temperature of the test conductors shall be measured at the point where they leave the enclosure and at a distance of 1 m externally along the temporary feeding connections. The temperature difference shall not exceed 5 K. However, in case this temperature difference exceeds 5 K, the test may be considered as valid if the above indicated point at 1 m from the assembly is the hottest and all criteria to pass the test defined in 7.5.6 are fulfilled.

7.5.5 Resistance of the main circuit

Subclause 7.5.5 of IEC 62271-1:2017 is applicable with the following addition:

The measured resistance, before the continuous current test, across the complete main circuit of an assembly is indicative of the proper condition of the current path. This measured resistance shall be the reference for the routine test (refer to 8.4).

7.5.6 Criteria to pass test

Subclause 7.5.6 of IEC 62271-1:2017 is applicable with the following additions to 7.5.6.1:

The temperature rise of assemblies containing components which are subject to individual component standards shall not cause these components to exceed their temperature limits as permitted in their relevant standard.

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.

7.5.101 Test report

In addition to the requirements of 7.1.3, in case the test object is equipped with high-voltage fuses, the following fuse information shall be included in the test report:

- manufacturer;
- type designation;
- rated voltage and rated current;
- power (in watts) dissipated by each individual (1-phase) fuse-link just before the end of the test period.

NOTE 1 The power dissipated by the fuse-link is defined by the product of the applied AC continuous test current (RMS value) and the measured steady voltage drop across the fuse-link.

NOTE 2 The voltage drop is measured on the fuse-link contacts as close as possible to the point of contact with the immediate mating contact piece.

7.6 Short-time withstand current and peak withstand current tests

7.6.1 General

Subclause 7.6.1 of IEC 62271-1:2017 is applicable with the following additions:

a) Test on main circuits

Main circuits of assemblies 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 assembly with all associated components influencing the performance or modifying the short-circuit current.

Parts of the main circuits which incorporate current-limiting fuses do not need to be tested if one of the conditions below is fulfilled:

– the making and breaking tests of the switching function incorporating the fuses have been performed within the assembly;

NOTE 1 An example of switching function incorporating current-limiting fuses is a switch-fuse combination.

– breaking tests of the fuses, when the fuses are not part of a switching function, have been performed within the assembly;

– a short-time withstand current test, with a solid metal link replacing the fuse-link, demonstrating that both the applied peak current and resulting thermal effects (i.e. Joule integral I^2t) are equal to or higher than, those which would be obtained with fuses at the rated voltage, has been performed within the assembly.

In all cases, the performed tests shall at least cover the situations of maximum breaking current (up to I_k and I_p of the branch of the assembly incorporating current-limiting fuses) and of maximum let-through I^2t for the fuses which can be used within the assembly according to the reference list provided by the manufacturer.

NOTE 2 The maximum let-through I^2t is generally obtained with a lower prospective current than I_k.

Connections to auxiliary devices (such as voltage transformers, auxiliary transformers, surge arresters, surge capacitors, voltage detection devices, and similar items) are not part of the main circuit (refer to 3.5.105).

b) Tests on earthing circuits

Earthing devices, earthing conductors, earthing connections and other conductive parts forming part of the earthing circuit of an assembly shall be tested to verify their capability to withstand their rated short-time and peak withstand currents (I_k, I_p, t_k and I_{ke}, I_{pe}, t_{ke} – as applicable). They shall be tested as installed in the assembly with all associated components influencing the performance or modifying the short-circuit current.

The short-time withstand current and peak withstand current tests shall be carried out on the short-circuiting parts of each earthing circuit according to the number of phases of the corresponding earthing device (I_k, I_p, t_k). Additionally, single-phase tests shall be performed on all parts of the earthing circuit that are designed to provide the connection between the earthing device and the earthing point provided, at the rated short-time and peak withstand currents (I_{ke}, I_{pe}, t_{ke}).

When there are removable earthing devices, the earthing connection(s) between the fixed part (of the assembly) and the removable earthing device shall be tested at the rated short-time and peak withstand currents (I_k, I_p, t_k and I_{ke}, I_{pe}, t_{ke} – as applicable). The current shall flow along the earthing conductor between the fixed part and the earthing point of the removable part. Additionally, where the earthing device in the assembly can be operated in alternative positions to the service position, the test shall be repeated for all alternative positions.

Each test shall be preceded by a no-load operation of the mechanical switching device(s) and by measurement of the resistance of the main circuit according to 7.4.4. The no-load opening operation shall be carried out at the rated value of the supply voltage in the case of power operated devices and the force/torque shall be measured in the case of dependent manually operated devices.

Earthing switches and earthing circuits are excluded from resistance measurement.

7.6.2 Arrangement of the equipment and of the test circuit

Subclause 7.6.2 of IEC 62271-1:2017 is not applicable.

The circuits of the test object shall be selected in such a way that the most onerous conditions are obtained concerning the maximum lengths of unsupported conductors, configuration of the conductors and connections within the equipment, and the assigned rated values. In the case of assemblies incorporating the same switching device at several locations, it also shall be checked that the most onerous location of the switching device is tested.

The test connections to the terminals of the assembly 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 assembly shall be in accordance with the manufacturer's instructions reference.

The short-time withstand current and peak withstand current tests shall be carried out according to the number of phases of the circuit under test. However, each earthing circuit shall be tested with its number of phases at its I_k, I_p and t_k, and tested single-phase at its I_{ke}, I_{pe} and t_{ke} up to the earthing point provided on the test object. These tests may be performed on different test samples. Parts of the earthing circuit already satisfactorily tested may be replaced between tests on different earthing circuits.

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 the rated voltage of the assembly, except if the test set-up at a lower voltage results in mechanical and thermal effects that are equal to, or higher than, those with the incorporated current-limiting device at rated voltage. Refer to 7.6.1 a) for further details on fuse-link selection, and accepted alternatives to demonstrate this performance.

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

NOTE The definition of self-tripping circuit-breakers is provided in 3.4.113 of IEC 62271-100:2021.

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

The test arrangement shall be noted in the test report.

7.6.3 Test current and duration

Subclause 7.6.3 of IEC 62271-1:2017 is applicable with the following additions:

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

The rated duration for these tests will be t_k or t_{ke}, whichever is applicable for the tested circuit.

7.6.4 Conditions of the test object after test

Subclause 7.6.4 of IEC 62271-1:2017 is applicable with the following additions:

The maximum acceptable increase of resistance for the complete main circuit of an assembly as condition check is considered to be satisfactory if this resistance increase does not exceed 20 % of the value measured before the test. If the resistance increase exceeds 20 % then a continuous current test (see 7.5) is applicable to determine if the test object can carry its rated continuous current.

After the test on each earthing circuit, some deformation and degradation of the earthing devices, earthing conductors, earthing connections and other conductive parts forming part of the earthing circuit 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 (DC) to the earthing point provided. The voltage drop shall be lower than 3 V.

7.7 Verification of the protection

7.7.1 Verification of the IP coding

Subclause 7.7.1 of IEC 62271-1:2017 is applicable with the following additions:

For verification of the IP coding, the service condition is with all doors and covers closed, no matter how they are expected to be locked or not.

Accessible partitions and shutters, as defined by the manufacturer, shall be verified on IP2X.

7.7.2 Verification of the IK coding

Subclause 7.7.2 of IEC 62271-1:2017 is applicable with the following addition:

For verification of the IK coding, the service condition is with all doors and covers closed, no matter how they are expected to be locked or not.

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2017 is applicable with the following additions to 7.8.1:

The tightness of each representative tight compartment shall also be tested once at the maximum ambient air temperature of the specified service conditions as defined in Clause 4 of IEC 62271-1:2017. The leakage rate shall stay within the limits defined in Table 15 of IEC 62271-1:2017.

For a defined type of switchgear and controlgear, a tight compartment design is considered to be validated if all types of sealings for a specific design are tested at least once on representative compartments.

These tests may be performed during other tests at temperature limits (if any) as specified in component standards.

7.9 Electromagnetic compatibility tests (EMC)

Subclause 7.9 of IEC 62271-1:2017 is applicable with the following addition to 7.9.1.2:

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

7.10 Additional tests on auxiliary and control circuits

7.10.1 General

Subclause 7.10.1 of IEC 62271-1:2017 is applicable with the following addition:

Where applicable, the tests under 7.10 shall be performed on a typical lay-out of the assembly, based on the standard wiring rules of the manufacturer.

7.10.2 Functional tests

Subclause 7.10.2 of IEC 62271-1:2017 is not applicable.

NOTE Functional tests on auxiliary and control circuits are performed as routine tests, refer to 8.3.2.

7.10.3 Verification of the operational characteristics of auxiliary contacts

Subclause 7.10.3 of IEC 62271-1:2017 is applicable with the following addition:

This subclause is not applicable to the auxiliary contacts already tested according to their own standard.

7.10.4 Environmental tests

Subclause 7.10.4 of IEC 62271-1:2017 is applicable with the following limitations:

– tests do not apply for indoor assemblies operated under normal service conditions as defined by 4.1.2 of IEC 62271-1:2017;
– when the tests as stated in 7.10.4 of IEC 62271-1:2017 have been performed on the separate components of a representative auxiliary and control circuit, no further environmental tests are needed.

7.10.5 Dielectric test

Subclause 7.10.5 of IEC 62271-1:2017 is applicable.

7.11 X-radiation test for vacuum interrupters

Subclause 7.11 of IEC 62271-1:2017 is applicable.

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

7.101 Verification of making and breaking capacities

7.101.1 General

Switching devices forming part of the main circuit and earthing switches of assemblies 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 assembly with all associated components that may influence the performance, such as connections, supports, provisions for venting. These tests are not necessary if making and breaking tests have been performed on the switching devices installed in assemblies with identical or more onerous conditions.

NOTE In determining which associated components are likely to influence the performance, the following can be relevant: 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 influence can be quite negligible. IEC TR 62271-307 lists the relevant design parameters that are considered to establish the same or less onerous conditions.

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 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 7.101.2 and 7.101.3 below shall be repeated in each of the compartments where these switching devices are installed;
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.

7.101.2 Test requirements for main switching devices

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

– IEC 62271-100:2021: test duties T100s, T100a, and critical current tests (if any) also taking into account the requirements of 6.103.4 of that standard for the test connection arrangement, where applicable. For circuit-breakers that are already type tested in alternative configurations for both k_{pp} = 1,5 and 1,3, then T100s and T100a only have to be demonstrated for k_{pp} = 1,5;

– IEC 62271-103:2021: Test duty TD_{load2} (10 CO operations). Where the switch has a rated short-circuit making capacity, the 10 CO operations of TD_{load2} shall be followed by test duty TD_{ma} according to class E1, E2 or E3, as applicable;

– IEC 62271-105:2021: Test duties TD_{lsc}, and the highest value of $TD_{ltransfer}$ and TD_{lto};

– IEC 62271-106:2021: Verification of coordination with SCPDs;

– IEC 62271-107:2019: Test duties TD_{lr}, and TD_{lsc} and TD_{lto};

– IEC IEEE 62271-37-013:2015: Test duties 1 and 2.

Refer to 7.4.4 for maximum allowed resistance increase along the main circuit after making and breaking tests.

7.101.3 Test requirements for earthing function

If the earthing function has an assigned class E1 or E2, it shall be tested in accordance with the requirements of IEC 62271-102:2018 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.

If the class E1 or E2 earthing function is performed by the main switching device in combination with a class E0 earthing switch, then the test requirements shall be the same as for a combined function earthing switch as defined in 7.101 of IEC 62271-102:2018. In this case the requirements of 7.101.8 and 7.101.9 of IEC 62271-102:2018 apply to both the class E0 earthing switch and the main switching device.

7.102 Mechanical operation tests

7.102.1 Switching devices and removable parts

All switching devices not previously tested as mounted in the assembly, shall be operated 50 times C-O, mounted in the assembly. Test conditions and criteria to pass the test are identical to the ones defined on each corresponding switching device standard for mechanical tests.

If a removable part is intended to be used as a disconnector, then the mechanical endurance shall be in accordance with IEC 62271-102:2018. Otherwise, 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 remain lower than 150 % of that required for the first operation.

The reliable operation of 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, shall be checked.

For functional units including several switching devices, the operations may be performed as part of a sequence of operations involving all these switching devices. If the insertion/removal of a removable part is involved in the sequence, the number of such sequences should be limited to 25. Any operations not included in this sequence should be separately tested.

In the case of manually operated equipment, the normal manual operation handle shall be used to perform the tests.

7.102.2 Mechanical and electromechanical interlocks and locking devices

The interlocks and locking devices shall be set in all positions intended to prevent:

– the operation of the switching devices;
– the access to operation interfaces;
– the insertion or withdrawal of removable parts.

The following tests shall be made in order to attempt to defeat the interlocks and locking devices:

a) 10 attempts to open any interlocked or locked door or cover;
b) 10 attempts to access or engage the operation interface, when access or engagement is prevented due to an interlocking or locking device (shutter, selector lever, etc.);
c) 20 attempts to operate the switching devices manually, when the operation interface is accessible;
d) 10 attempts to operate the switching device manually in the wrong direction shall be carried out in addition to, but anywhere in, the above sequence of 20 attempts;
e) 10 attempts to insert and 10 attempts to withdraw the removable parts;
f) in case of electrical interlocks, switch off the auxiliary power supply and carry out one attempt of items a) to e);
g) in case of automatic closing of shutters that can be made inoperative in order to retain them in the open position: check that the switching device cannot be returned to the service position before the automatic operation of the shutters is restored (refer to 6.103.3.1).

The normal manual operation handle (if any) shall be used to perform these tests.

During the tests, the following prospective force or torque shall be applied:

– force of 400 N on handles of doors, covers and actuators of drive mechanisms with the exceptions given below;
– force of 750 N on handles of drive mechanisms with an interlock or lock blocking the operating shaft;
– force of 100 N on handles of shutters, selectors, etc. preventing access to the operation interface;
– force of 100 N on small linear actuators like push-button, plunger, etc.;
– torque of 3 Nm on small rotating actuators like knobs.

The force shall be applied at the midpoint of the gripping part of the handle or actuator with the following considerations:

– For handles consisting of one or more levers, the gripping part shall be defined by the manufacturer before testing. In this case, two different scenarios are considered:
  - if intended for gripping with one hand, the gripping part shall not extend more than 100 mm from the end of the lever;
  - if intended for gripping with two hands next to each other, the gripping part shall not extend more than 200 mm from the end of the lever.
– For handles where the lever is extensible or sliding, the lever shall be at the longest possible length, and the full force shall be applied to only one of the gripping parts of the lever(s), if more than one exists.

Where operating handles and actuators incorporate a feature which limits the transmitted force or torque, the maximum test force or torque shall be limited to that which can be applied by the handle or actuator, provided that the handle or actuator is not interchangeable with other handles or actuators.

No adjustment shall be made to the switching devices, removable parts or interlocks during these tests.

The integrity of sliders or other devices preventing access to the operation interface shall be verified in accordance with 7.7.2 (verification of the IK coding).

Where mechanical interlocks are designed to prevent the operation of motorized switching devices, the following additional tests shall be performed using the motor:

– 20 attempts to operate the switching devices;
– 10 attempts to operate the switching device in the wrong direction shall be carried out in addition to, but anywhere in, the above sequence of 20 attempts.

110 % of the rated supply voltage of auxiliary circuits shall be applied for a duration of 2 s.

The interlocks are considered to be satisfactory if:

a) the switching devices cannot be operated;
b) access to the interlocked compartments is prevented;
c) the insertion and withdrawal of the removable parts are prevented;
d) the switching devices, removable parts and the interlocks are still operative and the effort to operate them before and after the tests, does not differ from the maximum hand operating forces (manual operation) or peak energy consumption (motor operation) by more than 50 %. In case of the test with 750 N, damage is acceptable, provided that the interlock still prevents operation.

NOTE These tests can be performed as part of the mechanical operations test sequence.

7.103 Pressure withstand test for gas-filled compartments

7.103.1 Pressure withstand test for gas-filled compartments with pressure relief devices

Each design of a gas-filled compartment equipped with its pressure relief devices(s) shall be subjected to pressure tests as follows:

– Adjacent compartments (if any) shall be set at a pressure not higher than the minimum functional pressure of those compartments. If the manufacturer's instructions reference allow for maintenance of those compartments, they shall be at atmospheric pressure. Alternatively, they even may be evacuated, if allowed by the manufacturer.

  NOTE 1 This test configuration covers the over-pressure behaviour under intended service conditions.

  NOTE 2 The design pressure (relative pressure) calculation already considers the situation of adjacent compartment evacuated, if allowed by the manufacturer.

– The ambient temperature shall be between 15 °C and 30 °C.

  NOTE 3 The temperature range is in accordance with ISO 4126-2.

– For all the following pressure tests, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min in order to reach a value of 1,3 times the design pressure of the compartment for a period of 1 min. The pressure relief device shall not operate and the compartment shall not show signs of distress or any distortion likely to affect the operation of the assembly.
– To determine the highest possible value at which the pressure relief device operates, two possible scenarios shall be considered:
  - if no certificate is available for the pressure relief device (for example, in case of integral pressure relief devices), the operating pressure of the pressure relief device shall be verified by testing 5 samples of the pressure relief on the specific compartment design;

- if a certificate according to ISO 4126-2 for the pressure relief device is available for the range of service temperatures and up to the design temperature, it shall be verified that the operating pressure is in the range given by the certificate by a single test on the specific compartment design.

– For both scenarios, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to the pressure relief device operates, as designed by the manufacturer.

- The opening pressure(s) shall be recorded in the type test report.
- A visual inspection of the orientation of the pressure relief device should be performed. The direction of escaping gases should be indicated in the test report.

– Then, a verification of the safety margin of the compartment with respect to the pressure relief operation shall be performed as follows:

- the pressure relief device shall be blocked or reinforced without impacting the withstand pressure of the compartment;
- then, the relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to the highest value where the pressure relief would operate (by certificate or test mentioned above) multiplied by a safety factor. Two possible cases shall be considered:
  – if a certificate is available for the pressure relief device for the range of service temperatures and up to the design temperature, the applied safety factor to the upper value of operation given by the certificate shall be 1,1;
  – if no certificate is available for the pressure relief device (for example, in case of integral pressure relief devices), the highest opening pressure recorded in the 5 previous tests is taken and the applied safety factor shall be 1,5.
- the test pressure level shall be maintained for 1 min;
- the compartment may be distorted, but it shall not rupture during the test.

7.103.2 Pressure withstand test for gas-filled compartments without pressure relief devices

Each design of a gas-filled compartment without pressure relief device shall be subjected to a pressure test according to the following procedure:

– Adjacent compartments (if any) shall be set at a pressure not higher than the minimum functional pressure of those compartments. If the manufacturer's instructions reference allow for maintenance of those compartments, they shall be at atmospheric pressure. Alternatively, they even may be evacuated, if allowed by the manufacturer.

NOTE 1 This test configuration covers the over-pressure behaviour under intended service conditions.

NOTE 2 The design pressure (relative pressure) calculation already considers the situation of adjacent compartment evacuated, if allowed by the manufacturer.

– The ambient temperature shall be between 15 °C and 30 °C.

– The relative pressure shall be increased with a pressure rise not exceeding 400 kPa/min up to three times the design pressure of the compartment, except for those with cast aluminium walls with design pressure above 300 kPa where the upper value shall be five times the design pressure. The test pressure level shall be maintained for 1 min. After the test, the compartment may be distorted but it shall not rupture.

7.104 Tests to verify the protection of persons against dangerous electrical effects

7.104.1 General

Subclause 7.104 is applicable to non-metallic partitions and shutters intended for protection from effects of live parts. When these partitions contain bushings, tests shall be carried out under the appropriate conditions, i.e. with the primary parts of the bushings disconnected and earthed.

Solid-insulation embedded high-voltage parts that are intended to remain live when accessing the high-voltage compartment shall be tested according to 6.104 of IEC 62271-201:2014.

7.104.2 Dielectric tests

a) The insulation between high-voltage live parts and the accessible surface of insulating partitions and shutters shall withstand the rated withstand voltages specified in 7.2.7.1 for voltage tests to earth and between poles. For the test set-up, refer to item a) of 7.2.6.

b) A representative sample of the insulating material shall withstand the power-frequency test voltage specified in item a) above. The appropriate test methods given in IEC 60243-1 [9] should be applied.

c) The insulation between high-voltage live parts and the inner surface of insulating partitions and shutters facing these shall be tested at 150 % of the rated voltage of the equipment for 1 min. For the test, the inner surface of the partition or shutter shall be earthed by applying a conductive layer of at least 100 cm^2, at the most onerous point. The test set-up shall be as specified in item a) of 7.2.6.

7.104.3 Measurements of leakage currents

When an assembly contains insulating partitions or insulating shutters, the following tests shall be made in order to check compliance with the requirement of item d) of 6.103.3.3.

The main circuit shall, at the discretion of the manufacturer, be connected either to a three-phase supply of power-frequency voltage equal to the rated voltage of the assembly, with one phase connected to earth, or to a single-phase supply of a voltage equal to the rated voltage, the live parts of the main circuit being connected together. For three-phase tests, three measurements shall be made with the different phases of the supply successively connected to earth. In the case of single-phase tests, only one measurement is necessary.

A metal foil shall be placed in the most unfavourable situation for the test on the accessible surface of the insulation providing the protection against contact with live parts. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations.

The metal foil shall be approximately circular or square, having an area as large as possible but not exceeding 100 cm^2. The enclosure and the frame of the assembly shall be earthed. The leakage current flowing through the metal foil to earth shall be measured with the insulation dry and clean.

The value of the leakage current measured shall not exceed 0,5 mA. If, as indicated in item d) of 6.103.3.3, the continuous path over insulating surfaces is broken by small gaps of gas or liquid, such gaps shall be shorted out electrically. If these gaps are incorporated to avoid the passage of the leakage current from live parts to accessible parts of insulating partitions and shutters, the gaps shall withstand the test voltages specified in 7.2.7.1 for voltage tests to earth and between poles.

It is not necessary to measure leakage currents if earthed metal parts are arranged in an appropriate manner to ensure that leakage currents cannot reach the accessible parts of the insulating partitions and shutters.

7.105 Internal arc test

7.105.1 General

The test is applicable to assemblies for which an internal arc classification has been assigned, covering the event of an arc fault within the enclosure or within components having housings which form part of the enclosure in normal operating conditions. The internal arc test makes allowance for effects acting on all parts of the enclosure, such as internal overpressure, thermal effects of the arc or its roots, the effects of ejected hot gases and glowing particles.

7.105.2 Test conditions

The test shall be carried out with the assembly in the following conditions:

– the position of high-voltage switching devices and withdrawable parts is set to realize the supply circuit according to A.5.1. All other equipment, for example measuring instruments and monitoring equipment shall be in the position as it is in normal service;

– all covers and doors of the assembly shall be closed and correctly secured. However, in case of accessibility type A, if any cover has to be removed and/or any door has to be opened to perform switching operations, the internal arc test shall be carried out with the cover and/or door removed;

– if handle flaps of switching devices do not automatically close after removing the handle, the internal arc test shall be performed with handle flaps in open position.

Every high-voltage compartment of representative functional units of the assembly shall be tested. More than one test object may be necessary to perform all the internal arc tests.

Compartments which are protected by type-tested current-limiting fuses shall be tested with the fuse type that causes the highest cut-off current (let-through current). The actual duration of the current flow will be controlled by the fuses. The tested compartment will be designated as 'fuse-protected'. The tests shall be performed at the rated voltage U_r.

Any device (e.g. protection relay) that can automatically trip the circuit before the end of the prospective duration of the test shall be made inoperative during the test. If compartments or functional units are equipped with devices intended to limit the duration of the arc itself by other means (e.g. by transferring the current to a metallic short-circuit), they shall be made inoperative during the test. However, if the manufacturer declares that these devices are an integral part of the design of the compartment or assembly which prevents to make them inoperative without modification of the construction of the compartment or the enclosure, the relevant compartment of the assembly may be tested with the device operative; but this compartment shall be qualified according to the actual duration of the arc. The test current shall be maintained for the rated short-circuit duration of the main circuit.

NOTE 1 For possible measures to mitigate the effects of internal arcs, refer to Cigré Technical Brochure 686 [11].

If, during the test, an arc ignites in another already arc-tested compartment of the same test object (see 7.105.3), the test is not valid. However, if during the test, an arc ignites in a non-previously arc-tested compartment(s) of the same test object, the test shall be regarded as valid for the compartment where the arc was initiated, under the condition that it can be proven that the ignition was the consequence of design construction, as declared by the manufacturer before the test. Examples of such design constructions are:

– a lower short-circuit withstand of part of the circuit, upstream in the current path from the compartment under test;

– burn-through, or opening of pressure relief flaps, to another compartment.

The manufacturer's declaration shall be referred to in the test report.

The other affected compartment(s) shall be (or shall have been) tested with the point of initiation as required in A.5.2.1. The number of phases to be tested shall be in accordance with A.5.2.1 and Table A.1 provided that the arc initiation involves at least the number of phases involved in this take-over ignition.

NOTE 2 Reason for not accepting the test result in case of transfer to a compartment that was already arc-tested, is that the test result can be influenced by the contamination in that compartment.

7.105.3 Arrangement of the equipment

The equipment shall be arranged as follows:

– the test object shall be fully equipped. Mock-ups of internal components are permitted provided they have the same volume and external material as the original items and they do not affect the main and earthing circuits;

– tests shall be performed on all types of functional units that may be combined into an assembly, as stated by the manufacturer regarding the different possible assembly lay-outs. The following applies:

  - in case of assemblies consisting of extensible (modular) functional units, the test object shall consist of two functional units connected together as in service, unless the manufacturer specifies a different minimum number of functional units;
  - if by design of the assembly, a type of functional unit is not intended to be used as an end unit under service conditions, for its test, it shall be configured in the assembly as close as possible to the lateral side – furthest away from the wall of the room simulation, in an arrangement of more than two functional units;
  - in case of assemblies with at least one high-voltage compartment belonging to more than one functional unit (e.g. several main switching devices in one compartment), the test object shall consist of functional units where the shared high-voltage compartment is complete;
  - the tests shall be made in all high-voltage compartments of a functional unit, as close as possible to the lateral side – furthest away from the wall of the room simulation;
  - in case of assemblies having functional units that contain identical high-voltage compartments with the same internal arc test conditions, one test on this type of compartment is sufficient, provided that the test object was placed as close as possible to the lateral side – furthest away from the wall of the room simulation, as stated by the manufacturer regarding the different possible assembly lay-outs;

– the test object shall be earthed at the earthing point provided;

– tests shall be carried out on compartments not previously subjected to arcing, or, if subjected, being in a condition which does not affect the result of the test;

– in case of fluid-filled compartments (other than SF_6) the test shall be made with the original fluid at its filling pressure (±10 % of the relative pressure) for insulation;

– for environmental reasons, it is recommended to replace SF_6 with air at the filling pressure for insulation and/or switching (±10 % of the relative pressure).

NOTE Test results with air instead of SF_6 are considered to be representative.

7.105.4 Test procedure

The method to verify the internal arc classification is defined in Clause A.5.

7.105.5 Criteria to pass the test

IAC classification according to the relevant type of accessibility, is demonstrated for the assembly if the following criteria are met:

Criterion No. 1

Correctly secured doors and covers do not open. Deformations are accepted, provided that no part comes as far as the position of the indicator mounting frames or the walls (whichever is the closest) on every side and no openings with dimensions larger than 50 mm occurred in the classified sides up to a height of 2 000 mm. The assembly does not need to comply with its IP code after the test.

To extend the acceptance criterion to an installation mounted closer to the wall than tested, two additional conditions shall be met:

– the permanent deformation is less than the intended distance to the wall;

– exhausting gases are not directed to the wall.

Criterion No. 2

– no fragmentation of the enclosure occurs;
– no ejection of fragments or of other parts of the assembly of an individual mass of 60 g or more occur;
– objects of an individual mass of 60 g or more falling to the floor in the immediate vicinity of the assembly are accepted (in the case of accessible sides, this means between the assembly and the indicator rack).

Criterion No. 3

Arcing does not cause holes by burning through in the classified sides up to a height of 2 000 mm.

NOTE 1 Holes in the enclosure which are created after the duration of the test by other effects than burning through, are disregarded.

Criterion No. 4

Indicators do not ignite during the test and within 1 s after the current duration. If indicators have been ignited after 1 s after the current duration and if proof is established of the fact that the ignition was caused by glowing particles rather than hot gases, the assessment criterion has also been met. Pictures taken by high-speed cameras, video or any other suitable means should be used by the test laboratory to establish evidence.

Indicators ignited as a result of paint or stickers burning are also excluded.

NOTE 2 It is assumed that the physical dimensions of the test laboratory are large enough to prevent hot gas reflections towards the indicators from surfaces not belonging to the room simulation (e.g. from other walls or measuring equipment).

Criterion No. 5

The enclosure remains connected to its earthing point. Visual inspection is generally sufficient to assess compliance. In case of doubt, the continuity of the earthing connection shall be checked (refer to 7.6.4).

7.105.6 Test report

In addition to 7.1.3 the following information shall be included:

– description of the test object with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the test object to the floor and/or to the walls;
– the distance between the upper part of the test object and the ceiling of the room or building. For this purpose, the manufacturer shall state the point of the assembly from which this distance is measured;

NOTE Because the distance between the upper part of the assembly and the ceiling under internal arc test conditions can be different from the distance under installation conditions, the information in the test report is about the validity of the test results regarding the ceiling height for installation.

– point and method of initiation of the internal arc fault;
– drawings of test arrangement (room simulation, test object and mounting frame of indicators) with respect to the type of accessibility (A or B), classified sides (F, L or R) and installation conditions;
– applied voltage and frequency;
– for the prospective and/or test current (refer to A.4.3):
  1) RMS value of the AC component during:

- the first three half-cycles;
- the last three half-cycles;

2) highest peak value (actual and/or prospective);
3) average RMS value of the AC component over the actual duration of the test;
4) duration of arc fault current;
5) prospective RMS value and duration of the test current.

– oscillogram(s) showing currents and voltages;
– optionally, total arc energy, peak arc power;
– optionally, measurement of pressure in compartments;
– assessment of the test results, including a record of the observations in accordance with 7.105.5 and observations regarding compartments where take-over ignition took place (if any);
– other relevant remarks.

7.105.7 Extension of validity of test results

The validity of the results of a test carried out in a functional unit of a particular metal-enclosed design of assembly may be extended to another one (refer to 7.1.1 and to IEC TR 62271-307:2015) provided that the original test was more onerous and this other functional unit may be considered as similar to the tested one in the following aspects:

– dimensions;
– structure and strength of the enclosure;
– architecture of the partition;
– performance of the pressure relief device, if any;
– insulation system;
– physical influences (pressure rise, gas flow and thermal effects).

8 Routine tests

8.1 General

Subclause 8.1 of IEC 62271-1:2017 is applicable, with the following additions:

– partial discharge measurement (if applicable): 8.101;
– mechanical operation tests: 8.102;
– pressure tests of gas-filled compartments (if applicable): 8.103;
– tests after erection on site: 8.104;
– measurement of fluid conditions after filling on site (if applicable): 8.105.

8.2 Dielectric test on the main circuit

Subclause 8.2 of IEC 62271-1:2017 is applicable, with the following additions and exceptions:

The power-frequency voltage test shall be performed according to the requirements in 7.2.7.2. The test voltage specified in 7.2.7.1 for U_d, common value, from column 2 of Tables 1 and 2 of IEC 62271-1:2017, shall be applied, connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply, with the other phase conductors connected to earth and the continuity of the main circuit ensured (e.g. by closing the switching devices or otherwise).

The test voltage may be applied at higher than the rated frequency in order to avoid the disconnection of voltage transformers.

Overvoltage protective devices shall be disconnected or removed during the test.

8.3 Tests on auxiliary and control circuits

8.3.1 Inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams

Subclause 8.3.1 of IEC 62271-1:2017 is applicable.

8.3.2 Functional tests

Subclause 8.3.2 of IEC 62271-1:2017 is replaced by:

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 assembly.

Functional tests as specified in the relevant IEC component standards shall be performed on auxiliary and control circuits of each component, subassembly or after mounted on the assembly.

Additionally, all existing auxiliary and control circuits (including electrical interlocks) shall be verified on their proper operation in conjunction with the other parts of the assembly.

The tests shall be performed with the upper and lower value limits of the supply voltage defined in 6.9 of IEC 62271-1:2017.

8.3.3 Verification of protection against electrical shock

Subclause 8.3.3 of IEC 62271-1:2017 is applicable.

8.3.4 Dielectric tests

Subclause 8.3.4 of IEC 62271-1:2017 is applicable.

8.4 Measurement of the resistance of the main circuit

Subclause 8.4 of IEC 62271-1:2017 is applicable with the following addition:

Where there is no continuous current test for the configuration being tested, the conditions of the test and the limits of resistance values shall be given by the manufacturer.

8.5 Tightness test

Subclause 8.5 of IEC 62271-1:2017 is applicable with the following modification:

Tightness tests shall be performed after the pressure withstand tests according to 8.103, if any.

8.6 Design and visual checks

Subclause 8.6 of IEC 62271-1:2017 is applicable.

8.101 Partial discharge measurement

This test is optional. If such a routine test is performed on the assembly, the procedure shall be in accordance with Annex B.

NOTE The measurement of partial discharges, as a routine test, can be helpful to detect possible material and manufacturing defects especially for organic solid insulating components. The test can also serve as a quality manufacturing test of assembly.

8.102 Mechanical operation tests

Operation tests shall be made to ensure that the switching devices, removable parts and auxiliary circuits function correctly and that the mechanical interlocks work properly.

The tests shall be performed as specified in 7.102 except that:

– in case of manual operation, 5 operations or attempts shall be performed in each direction with normal operating forces;

– in case of auxiliary supply voltage, and switching devices not tested within the functional unit, 5 operations or attempts shall be performed in each direction, both for the specified upper and lower limit of the auxiliary supply voltage of the operating devices;

– devices having a predetermined sequence of operation, shall be operated:

  • with the most unfavourable limit values of auxiliary supply voltage;

  • 5 times in succession in the intended conditions of use and operation;

It shall be verified that:

– the switching devices open and close correctly within the specified limits of the supply voltage and pressure of their operating devices;

– each removable part can be inserted and removed correctly;

– the interchangeability of removable components of the same rating and construction is checked (refer to 6.101);

– all interlocks function correctly;

– all auxiliary devices have operated properly;

– the effort to operate is practically the same before and after the tests.

8.103 Pressure tests of gas-filled compartments

Each gas-filled compartment with a filling pressure above 150 kPa (absolute pressure) shall withstand during 1 min:

– 2,0 times the design pressure for cast resin, ceramic or cast aluminium gas-filled compartments without pressure relief device;

– 1,3 times the design pressure in other cases.

After this test the compartment shall show no signs of distress or any distortion likely to affect the operation of the assembly.

8.104 Tests after erection on site

After erection, the assembly shall be tested to check correct operation.

All routine tests of Clause 8 which have not been performed at the manufacturer's premises shall be performed on site.

Additionally, for parts which are assembled on site and for compartments which are gas or liquid filled on site and which all have been previously routine tested, the following is applicable:

a) Voltage test of the main circuit;

   Power-frequency voltage tests in dry conditions should be carried out on the main circuits of an assembly after the erection on site in exactly the same manner as specified in 8.2 for the routine test at the manufacturer's premises.

The power-frequency test voltage should be 80 % of the values indicated in 8.2 and be applied to each phase conductor of the main circuit in succession with the other phase conductors earthed. For the tests, one terminal of the test transformer is connected to earth and to the enclosure of the assembly.

Voltage transformers should be disconnected during dielectric site tests, unless the test frequency used for the site test is high enough to prevent core saturation;

b) Tightness tests: 8.5 is applicable;

c) Measurement of fluid condition after filling on site: 8.105 is applicable.

8.105 Measurement of fluid condition after filling on site

The condition of the fluid in fluid-filled compartments shall be determined and shall meet the manufacturer's specification.

9 Guide to the selection of switchgear and controlgear (informative)

9.1 General

Subclause 9.1 of IEC 62271-1:2017 is applicable with the following additions:

Assemblies may be constructed in various forms that have evolved with changing technologies and functional requirements. The selection of an assembly essentially involves an identification of the functional requirements for the service installation and the form of internal partitioning that best meets these requirements.

Such requirements should take account of applicable legislation and user safety rules.

Table 4 provides a summary of the considerations for specifying an assembly.

9.2 Selection of rated values

Subclause 9.2 of IEC 62271-1:2017 is applicable with the following additions:

For a given duty in service, the assembly is selected by considering the individual rated values of their components required by normal load and fault conditions. The rated values of an assembly may differ from those of its component parts.

The rated values should be chosen in accordance with this document having regard for the characteristics of the system as well as its anticipated future development. The list of ratings is given in Clause 5.

Other parameters such as local atmospheric and climatic conditions and the use at altitudes exceeding 1 000 m should also be considered.

The duty imposed by fault conditions should be determined by calculating the fault currents at the place where the assembly is to be located in the system. Reference is made to IEC 60909-0 in this regard [12].

9.3 Cable-interface considerations

Subclause 9.3 of IEC 62271-1:2017 is applicable with the following additions:

Users should select the type of terminations from a list provided by the manufacturer of the assembly.

Users should specify values of rated cable test voltages allowing adequate margins above the actual cable test voltages expected to be applied.

9.4 Continuous or temporary overload due to changed service conditions

Subclause 9.4 of IEC 62271-1:2017 is applicable.

9.5 Environmental aspects

Subclause 9.5 of IEC 62271-1:2017 is applicable.

9.101 Selection of design and construction

9.101.1 General

An assembly is generally identified by insulating technology (e.g. air- or gas-insulated) and by fixed or withdrawable design. The extent to which individual components should be withdrawable, or removable, is primarily dependent upon the requirement (if any) for maintenance and/or the provisions for testing. The operating instructions defined by the manufacturer should be considered for normal use, for example for the opening of the door of a procedure-based or interlock-based accessible connection compartment.

Development of switching devices with low maintenance requirement has reduced the need for frequent attention to some items subject to arc erosion. However, there remains a need for accessibility to expendable items, for example fuses, and for occasional inspection and testing of cables. Lubrication and adjustment of some mechanical parts can also be required for some designs.

The extent to which access may be required for maintenance, and/or whether complete assembly shutdowns may be tolerated, may determine a user preference for air or fluid insulation and fixed or withdrawable pattern. If maintenance demands are infrequent, as is often preferred practice nowadays, then assemblies equipped with low-maintenance components, may provide a practical solution. Fixed pattern assemblies, particularly those employing low-maintenance components, may provide a cost-effective through-life arrangement.

9.101.2 Architecture and accessibility to high-voltage compartments

The forms of internal partitioning defined in this document attempt to balance requirements as service continuity and maintainability. In this subclause, some guidance is given regarding the extent to which the different forms can provide maintainability.

NOTE 1 Temporary inserted partitions, to prevent accidental contact with live parts while performing certain maintenance procedures, are addressed in 11.5.

NOTE 2 Possible alternative maintenance procedures, e.g. the establishment of safety distances and/or setting up and use of temporary barriers, are outside the scope of this document.

The complete description of an assembly includes the list and type of high-voltage compartments, e.g. busbar compartment, circuit-breaker compartment, etc., the type of accessibility provided to each and the pattern (withdrawable/non-withdrawable).

There are four types of high-voltage compartments, three being accessible to the user and one non-accessible.

For accessible high-voltage compartments there are three methods of controlling the opening of these compartments:

– the first is by use of interlocks to ensure that all live parts inside are isolated and earthed before opening or are in the disconnected position with corresponding shutters closed. Such compartments are designated "interlock-controlled accessible compartments";

NOTE 3 Generally, it can be possible to open shutters or temporary inserted partitions manually after accessing the high-voltage compartment.

– the second relies on user procedure and locking to ensure safety, the compartment being supplied with facilities for padlocking or equivalent; this type of compartment is designated a "procedure-based accessible compartment";

– the third does not provide any built-in feature to ensure electrical safety before opening. Such compartments need tools to be opened; they are designated "tool-based accessible compartments".

The first two types of accessible high-voltage compartment are available to the user to be opened for normal use (see 3.1.107). The opening of these two types of accessible high-voltage compartments can additionally require manipulating some fixing elements for opening. These compartments can also have other covers and/or doors requiring tools for opening following a proper procedure and identified with specific warning labels about the electrical risk behind if opened or removed.

If the access to a high-voltage compartment is only limited by the need of tools for opening, then this is a clear indication that this compartment is not designed for opening in normal use. The user should take other measures to ensure safety, and possibly to ensure performance integrity, e.g. insulating conditions. When made accessible, attention should be paid to the requirement (if any) to operate the switching devices without voltage/current on the main circuit with doors and covers open as part of the maintenance procedures. When made accessible, attention should be paid to the requirement (if any) to operate the switching devices without voltage/current on the main circuit with doors and covers open as part of the maintenance procedures.

Non-accessible high-voltage compartments (see 3.5.113) should not be opened by the user as the opening could destroy the integrity of the compartment. Sometimes, a indication not to open is provided on, or is evident by a feature of the compartment, e.g. a completely welded GIS tank. However, by default, every high-voltage compartment not declared accessible by the manufacturer in the manufacturer's instructions reference, is considered as a non-accessible compartment.

9.101.3 Service continuity of the switchgear

The metal-enclosure is intended to provide a level of protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects. With appropriate sensing and auxiliary control devices, it is also possible to provide a level of protection against failure of insulation.

For each functional unit of an assembly, the Loss of Service Continuity category (LSC) describes the extent to which other high-voltage compartments and/or functional units may remain energised when the connection compartment or any other high-voltage compartment of this functional unit accessible in normal use is opened. See 3.5.110 and 3.5.111.

Category LSC1: this form is not intended to provide service continuity when opening any accessible compartment of the functional unit for normal use. Complete disconnection of the functional unit from the system and the isolation and earthing of the high-voltage conductive parts is required before opening any compartment.

Category LSC2 family: these forms are intended to allow maximum continuity of service of the network during access to the high-voltage compartments of the functional unit accessible in normal use. It means that opening of accessible high-voltage compartments of a functional unit in normal use is possible while keeping the other functional units of the same section energised. This implies that at least one busbar may be kept energised. Insertion of a movable partition may be used to achieve this category, refer to 11.5.

LSC2 requires as a minimum that it is possible to open the connection compartment of the functional unit while keeping the busbar(s) live. There may or may not be other high-voltage compartments that are accessible in normal use (e.g. main switching device compartment).

LSC2A is applicable to a functional unit that has compartments (at least one), other than the high-voltage connection compartment, that are accessible in normal use (for instance the main switching device compartment); this requires that it is allowed, after isolating and earthing the relevant high-voltage circuit, or moving the withdrawable part to the disconnected position with corresponding shutters closed, to open such high-voltage compartment while keeping the busbar(s) energised (it is of course not allowed to open the live busbar compartment(s) unless the live conductors are embedded by solid insulation material and comply with at least protection category PA of IEC 62271-201:2014).

It could be of additional value to keep the high-voltage connection (e.g. cables) energized when accessing such other compartments of the corresponding functional unit. This situation can occur when alternative power supplies are part of the installation (loop operation, generators, etc.). For these situations assemblies may be specified to be LSC2B; this requires that the connection (cable) compartment may be kept energized when any other accessible high-voltage compartment is open.

The three categories of the LSC2 family can be summarized as follows:

– LSC2: Designation for functional units with accessible high-voltage connection compartments where opening the connection compartment does not require the busbar(s) nor the other functional units to be put out of service;
– LSC2A: Designation dedicated to LSC2 functional units in which all accessible high-voltage compartments (other than the busbar of single busbar equipment) may be opened with a busbar live;
– LSC2B: In addition to the requirements of LSC2A, the high-voltage connections (e.g. cables) to the functional unit being accessed may be kept energized. This implies that there also is a point of disconnection, as well as proper partitioning, between the accessed compartment and the high-voltage connections.

Examples:

1) LSC1 (Figure 1): a circuit-breaker functional unit with cable connections in the same compartment as the circuit-breaker and busbar will be categorized as LSC1.
2) LSC2 (Figure 2): a non-withdrawable circuit-breaker functional unit has two accessible high-voltage compartments (other than the busbar compartment), and a disconnector in the circuit-breaker compartment. It is not allowed to open the circuit-breaker compartment with the busbar live. However, the high-voltage connection may be earthed via the circuit-breaker: if there is full partitioning between the connection compartment and the circuit-breaker compartment, then the connection compartment may be opened with the busbar live. The functional unit should be categorized as LSC2.
3) LSC2 (Figure 3): a circuit-breaker functional unit with cable connections in the same compartment as the circuit-breaker, this compartment being accessible with the busbar live because it can be isolated and earthed by disconnector and earthing switch placed in the busbar compartment.
4) LSC2 (Figure 4): Similar to Figure 3, a typical ring main unit design (RMU) where the busbar compartment contains the switch-disconnectors or circuit breakers of several functional units is also categorized as LSC2.
5) LSC2A (Figure 5): this is similar to example 2, except that the disconnector is located in the busbar compartment, and there is full partitioning between the busbar and circuit-breaker compartments. Both the circuit-breaker compartment and the connection compartment may be opened safely with the busbar live after the disconnector is opened and the earthing switch is closed. Access to the circuit-breaker compartment requires that the cables are isolated and earthed.