IEC 62271-214

Edition 2.0 2024-04
EXTENDED VERSION

INTERNATIONAL STANDARD

colour inside

This extended version of IEC 62271-214:2024 includes the content of the references made to IEC 62271-1:2017+AMD1:2021 CSV

High-voltage switchgear and controlgear – Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

IEC 62271-214:2024-04 EXV(en)

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

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This extended version (EXV) of the official IEC Standard provides the user with the comprehensive content of the Standard.

IEC 62271-214:2024 EXV includes the content of IEC 62271-214:2024, and the references made to IEC 62271-1:2017+AMD1:2021 CSV.

The specific content of IEC 62271-214:2024 is displayed on a blue background.

IEC 62271-214 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2019. This edition constitutes a technical revision.

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

a) indicators positioning update;
b) neutral earthing connection of the test circuit for three-phase tests;
c) general review for consistency with IEC 62271-200, Ed.3.0:2021.

The text of this International Standard is based on the following documents:

Draft	Report on voting
17C/924/FDIS	17C/931/RVD

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

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/publications.

This standard shall be read in conjunction with IEC 62271-1, second edition, published in 2017, to which it refers, and which is applicable unless otherwise specified in this standard. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1. Amendments to these clauses and subclauses are given under the same references whilst additional subclauses are numbered from 101. Any clause with the term "Not applicable" relates to the clause not being relevant to IEC 62271-214, and does not infer the clause is or is not relevant for its applicable switchgear standard.

A list of all parts of 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 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 document 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

In the preparation of this FDIS draft for the general revision of IEC 62271-1:2007 and IEC 62271-1:2007/AMD1:2011, the maintenance team was motivated by the following principles:

– Application of horizontal standards – such application is mandatory for product standards, (reference IEC Guide 108 [5]). A typical example is the application of IEC 60071 (all parts) dealing with insulation coordination.

– Application of the "principle of verifiability" – as defined in the Directives, Part 2, 5.5 (2016) “...Only those requirements which can be verified shall be included.”.

– Organizing information in the proper clause, e.g. terms and definitions in Clause 3, rated values in Clause 5. For example, the values of rated continuous current are specified in Clause 5 but the conditions of test and acceptance criteria (e.g. temperature rise limits) are moved to Clause 7.

– Normal service conditions in Clause 4 are unambiguous statements of conditions under which the switchgear and controlgear is expected to operate. For example: “Solar radiation does not exceed a level of 1 000 W/m^2” rather than “Solar radiation up to a level of 1 000 W/m^2 should be considered”.

– Ratings in Clause 5 have been limited to reflect the common specifications of the switchgear and controlgear that are specified by the user and are necessary for operation on the user‘s network. See the last paragraph of 5.1 for addition clarification.

– Statements or informative NOTES that reflect design guides (not requirements) or application (not standard requirements) are either removed or moved to Clause 9.

  For example, the following former NOTE contains both a design guide and an application issue, neither of which belongs to normal service conditions:
  “Under certain levels of solar radiation, appropriate measures, for example roofing, forced ventilation, test simulating solar gain, etc, may be necessary, or derating may be used, in order not to exceed the specified temperature rises and pressure rise limits”.

– Specifications for design and construction in Clause 6 have been limited to requirements that can be verified by test or inspection.

– References to tests and procedures that relate to transportation, installation, commissioning and maintenance have been moved to Clause 11.

– Improve wording to minimize the possibility of miss-interpretation or conflicting interpretations of the specifications, methods or criteria.

– Elimination of hanging paragraphs and actual or potential circular references. Reference to ISO/IEC Directives, Part 2, 22.3.3 (2016).

As a result of the application of these principles or objectives, the FDIS draft includes more revisions than might otherwise be expected.

INTRODUCTION to IEC 62271-214:2024

IEC 62271-214 has been developed due to the requirement to remove IAC Type C designated pole-mounted switchgear from IEC 62271-200. IEC 62271-214 is to be considered independent of IEC 62271-200, however it is still related to other product standards of the IEC 62271 series.

Only open terminal pole-mounted switchgear and controlgear has been considered within this document.

This equipment relates to operation in three-phase, two-phase and single-phase systems.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

1 Scope

This part of IEC 62271 specifies requirements for internal arc classification of AC metal-enclosed pole-mounted switchgear and controlgear with rated voltages above 1 kV and up to and including 52 kV with service frequencies up to and including 60 Hz.

This document is applicable to three-phase, two-phase and single-phase open terminal equipment for which an internal arc classification is assigned. Enclosures may include fixed and removable components and may be filled with fluid (liquid or gas) to provide insulation.

NOTE 1 The IAC classification takes into account the installation disposition of the high-voltage switchgear and controlgear and worker's operating area.

NOTE 2 For the use of this document, high-voltage (IEC 60050-601:1985, 601-01-27) is the rated voltage above 1 000 V. However, medium voltage (IEC 60050-601:1985, 601-01-28) is commonly used for distribution systems with voltages above 1 kV and generally applied up to and including 52 kV; refer to [1][1].

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

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 60038:2009, *IEC standard voltages*

IEC 60050-131:2002, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory*

IEC 60050-151:2001, International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014
IEC 60050-151:2001/AMD3:2019
IEC 60050-151:2001/AMD4:2020
IEC 60050-151:2001/AMD5:2021

IEC 60050-192:2015, *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability*

[1] Numbers in square brackets refer to the Bibliography.

IEC 60050-351, *International Electrotechnical Vocabulary (IEV) – Part 351: Control technology*

IEC 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics*

IEC 60050-581:2008, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment*

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60050-605, *International Electrotechnical Vocabulary (IEV) – Chapter 605: Generation, transmission and distribution of electricity – Substations*

IEC 60050-614:2016, *International Electrotechnical Vocabulary (IEV) – Part 614: Generation, transmission and distribution of electricity – Operation*

IEC 60050-811, *International Electrotechnical Vocabulary (IEV) – Part 811: Electric traction*

IEC 60050-826:2004, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations*

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

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*
IEC 60071-1:2006/AMD1:2010

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60255-21-1:1988, *Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section One: Vibration tests (sinusoidal)*

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

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

IEC 60507, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems*

IEC 60512-2-2, *Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2b: Contact resistance – Specified test current method*

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

IEC TS 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

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

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-17:2009, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*

IEC 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-5, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*

IEC 61180, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61810-7:2006, *Electromechanical elementary relays – Part 7: Test and measurement procedures*

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 62271-1:2017/AMD1:2021

IEC 62271-4, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF_6) and its mixtures*

IEC 62271-200:2021, *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*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*

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, as well as the following apply.

NOTE 1 The classification system for definitions of IEC 62271-1:2017 is not 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 terminology databases for use in standardization at the following addresses:

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

NOTE 2 Additional definitions are classified so as to be aligned with the classification system used in IEC 60050-441.

3.1 General terms and definitions

3.1.1
switchgear and controlgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:2000, 441-11-01]

3.1.2
external insulation
distances in atmospheric air and along the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other environmental conditions from the site

Note 1 to entry: Examples of environmental conditions are pollution, humidity, vermin, etc.

[SOURCE: IEC 60050-614:2016, 614-03-02]

3.1.3
degree of protection
extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or ingress of water and against mechanical impact

[SOURCE: IEC 60529:1989, 3.3, modified – leave out “verified by standardized test methods” and add “against mechanical impact” after "water and".]

3.1.4
IP code
coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection

[SOURCE: IEC 60529:1989, 3.4]

3.1.5
protection provided by an enclosure against access to hazardous parts
protection of persons against

– contact with hazardous low-voltage live parts;
– contact with hazardous mechanical parts;
– approach to hazardous high-voltage live parts below adequate clearance inside an enclosure

Note 1 to entry: This protection may be provided:

– by means of the enclosure itself;
– by means of barriers as part of the enclosure or distances inside the enclosure.

[SOURCE: IEC 60529:1989, 3.6]

3.1.6
IK code
coding system to indicate the degree of protection provided by an enclosure against harmful external mechanical impacts

[SOURCE: IEC 62262:2002, 3.3]

3.1.7
maintenance
combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

Note 1 to entry: Management is assumed to include supervision activities.

[SOURCE: IEC 60050-192:2015, 192-06-01]

3.1.8
visual inspection
visual investigation of the principal features of the switchgear and controlgear

Note 1 to entry: This inspection is generally directed toward pressures and/or levels of fluids, tightness, position of relays, pollution of insulating parts, but actions such as lubricating, cleaning, washing, etc. which can be carried out with the switchgear and controlgear in service are also included.

Note 2 to entry: Observations resulting from inspection can lead to the decision to carry out overhaul.

Note 3 to entry: This inspection can be used for determining the state of tested objects on e.g. cracks in solid insulators.

3.1.9
diagnostic test
comparative test of the characteristic parameters of switchgear and controlgear to verify that it performs its functions, by measuring one or more of these parameters

Note 1 to entry: The result from a diagnostic test can lead to the decision to carry out overhaul.

3.1.10
overhaul
work performed with the objective of repairing or replacing parts which are found to be out of tolerance by inspection, diagnostic test, examination or as required by manufacturer's maintenance manual, in order to restore the component and/or the switchgear and controlgear to an acceptable condition (within tolerance)

3.1.11
failure
loss of ability to perform as required

Note 1 to entry: A failure of an item is an event that results in a fault of that item: see fault (IEC 60050-192:2015, 192-04-01).

Note 2 to entry: Qualifiers, such as catastrophic, critical, major, minor, marginal and insignificant, can be used to categorize failures according to the severity of consequences, the choice and definitions of severity criteria depending upon the field of application.

Note 3 to entry: Qualifiers, such as misuse, mishandling and weakness, may be used to categorize failures according to the cause of failure.

[SOURCE: IEC 60050-192:2015, 192-03-01]

3.1.12
major failure (of switchgear and controlgear)
failure of switchgear and controlgear which causes the cessation of one or more of its fundamental functions

Note 1 to entry: A major failure may result in an immediate change in the system operating conditions, for example, the backup protective equipment will be required to remove the fault or will result in mandatory removal from service within 30 min for unscheduled maintenance.

3.1.13
minor failure (of switchgear and controlgear)
any failure of a constructional element or a subassembly which does not cause a major failure of the switchgear and controlgear

3.1.14
defect
imperfection in the state of an item (or inherent weakness) which can result in one or more failures of the item itself, or of another item under the specific service or environmental or maintenance conditions, for a stated period of time

3.1.15
ambient air temperature
temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse

Note 1 to entry: For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

[SOURCE: IEC 60050-441:2000, 441-11-13]

3.1.16
monitoring
observation of the operation of a system or part of a system to verify correct functioning by detecting incorrect functioning, this being done by measuring one or more variables of the system and comparing the measured values with the specified values

Note 1 to entry: Some definitions are given for this term in IEC 60050 (all parts). They are related to different cases of application.

3.1.17
supervision
activity, performed either manually or automatically, intended to observe the state of an item

Note 1 to entry Automatic supervision may be performed internally or externally to the item.

3.1.18
site pollution severity class
SPS
classification of pollution severity at a site, from very light to very heavy, as a function of the SPS (site pollution severity)

Note 1 to entry: Adapted from: IEC TS 60815-1:2008, 3.1.15, modified – the term (site pollution severity) is added.

3.1.19
internal insulation
internal distances of the solid, liquid or gaseous parts of the insulation of equipment which are protected from the effects of atmospheric and other external conditions

[SOURCE: IEC 60050-614:2016, 614-03-03, modified – addition of "parts of".]

3.1.20
non-sustained disruptive discharge
NSDD
disruptive discharge associated with current interruption that does not result in the resumption of power frequency current or, in the case of capacitive current interruption, does not result in current in the main load circuit

3.1.101
metal-enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external metal enclosure intended to be earthed, and completely assembled except for external connections

[SOURCE: IEC 60050-441:1984, 441-12-04, modified – "complete" has been replaced by "completely assembled"; NOTE has been deleted.]

3.1.102
enclosure
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, modified – <of an assembly> has been deleted.]

3.1.103
high-voltage compartment
compartment of switchgear and controlgear, containing high-voltage conducting parts, enclosed except for openings necessary for interconnection, control or ventilation, where one segment of the compartment can be part of the outer earthed metallic enclosure

3.1.104
component
essential part of the high-voltage or earthing circuits of pole-mounted switchgear and controlgear which serves a specific function (e.g. circuit-breaker, disconnector, switch, fuse, instrument transformer, bushing, busbar)

3.1.105
main circuit
all the high-voltage conductive parts of pole-mounted switchgear and controlgear included in a circuit which is intended to carry the rated continuous current

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – "high voltage" has been added, "assembly" has been substituted by "pole-mounted switchgear and controlgear" and "transmit electrical energy" has been substituted by "carry the rated continuous current".]

3.1.106
earthing circuit
conductors, connections, and the conducting parts of earthing devices intended to connect the high-voltage conductive parts to the earthing system of the installation

Note 1 to entry: Parts of metallic enclosures connected to the earthing system can be part of the earthing circuit.

3.1.107
normal operating condition
in service condition with all covers properly closed and secured

Note 1 to entry: The term "in service" implies "under live conditions".

[SOURCE: IEC 62271-200:2021[2], 3.1.106, modified – "<of an assembly>" and "doors and" have been removed and Note 1 to entry has been added.]

3.1.108
pressure relief device
device incorporated as part of an enclosure or compartment intended to operate to prevent excessive pressure in the enclosure or compartment

3.1.109
fluid-filled compartment
high-voltage compartment of pole-mounted switchgear and controlgear filled with a fluid, either gas, other than ambient air, or liquid, for insulation purposes

3.1.110
pole
vertical single member support in wood, concrete, steel or other material, with one end buried in the ground, either directly or by means of a foundation

Note 1 to entry: The term pole as defined here is not to be mixed up with the use of the same term as synonymous for phase as used in other standards.

[SOURCE: IEC 60050-466:1990, 466-07-01[8], modified – Note 1 to entry has been added.]

3.1.111
pole-mounted switchgear and controlgear
metal-enclosed switchgear and controlgear, typically connected to overhead lines, installed on one or more poles or equivalent structures at a defined height, with restricted accessibility by installation out of reach

3.1.112
internal arc classification
IAC
metal-enclosed switchgear and controlgear for which prescribed criteria, for protection of authorized persons and the general public beneath the apparatus, 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 described by the characteristics given from 3.1.114 to 3.1.116.

[SOURCE: IEC 62271-200:2021, 3.6.117, modified – "authorized" and "and general public beneath the apparatus" have been added, "assembly" has been changed by "metal-enclosed switchgear and controlgear".]

3.1.113
arc fault current
three-phase and where applicable the single-phase-to-earth RMS value of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

[SOURCE: IEC 62271-200:2021, 3.7.101]

3.1.114
arc fault duration
duration of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

[SOURCE: IEC 62271-200:2021, 3.7.102]

3.1.115
approach distance
distance between the test object and indicators arranged in an IAC test

3.1.116
arc mitigation device
device dedicated to reacting to internal arc fault conditions to decrease the arc energy

[SOURCE: CIGRE TECHNICAL BROCHURE 686:2017][5]

3.2 Assemblies of switchgear and controlgear

3.2.1
test object
equipment needed to represent the switchgear and controlgear for a particular type test

3.3 Parts of assemblies

3.3.1
transport unit
part of switchgear and controlgear intended for transportation without being dismantled

3.3.2
busbar
low-impedance conductor to which several electric circuits can be connected at separate points

Note 1 to entry: In many cases, the busbar consists of a bar.

[SOURCE: IEC 60050-151:2001, 151-12-30]

3.4 Switching devices

3.4.1
(mechanical) switch
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short-circuit

Note 1 to entry: A switch may be capable of making but not breaking short-circuit currents.

[SOURCE: IEC 60050-441:2000, 441-14-10]

3.4.2
disconnector
mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements

Note 1 to entry: A disconnector is capable of opening and closing a circuit when either negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying currents for a specified time under abnormal conditions such as those of short-circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05]

3.5 Parts of switchgear and controlgear

3.5.1
enclosure
housing affording the type and degree of protection suitable for the intended application

Note 1 to entry: Enclosures provide protection of persons or livestock against access to hazardous parts. Barriers, shapes of openings or any other means (whether attached to the enclosure or formed by the enclosed equipment) suitable to prevent or limit the penetration of the specified test probes, are considered as a part of the enclosure, when they are secured in position either by means of interlocks, keys, or by hardware requiring a tool to be removed.

[SOURCE: IEC 60050-826:2004, 826-12-20, modified – the Note 1 to entry has been added]

3.5.2
hazardous part
part that is hazardous to approach or touch

[SOURCE: IEC 60529:1989, 3.5]

3.5.3
contact (of a mechanical switching device)
conductive parts designed to establish circuit continuity when they touch and which, due to their relative motion during an operation, open or close a circuit or, in the case of hinged or sliding contacts, maintain circuit continuity

[SOURCE: IEC 60050-441:2000, 441-15-05]

3.5.4
auxiliary circuit (of a switching device)
all the conductive parts of a switching device which are intended to be included in a circuit other than the main circuit, the earthing circuit and the control circuits of the device

Note 1 to entry: Some auxiliary circuits fulfil supplementary functions such as signalling, interlocking, etc., and, as such, they may be part of the control circuit of another switching device.

[SOURCE: IEC 60050-441:2000, 441-15-04, modified – "earthing circuit" has been added]

3.5.5
control circuit (of a switching device)
all the conductive parts (other than the main circuit) of a switching device which are included in a circuit used for the closing operation or opening operation, or both, of the device

[SOURCE: IEC 60050-441:2000, 441-15-03]

3.5.6
auxiliary switch (of a mechanical switching device)
switch containing one or more control and/or auxiliary contacts mechanically operated by a switching device

[SOURCE: IEC 60050-441:2000, 441-15-11]

3.5.7
control switch (for control and auxiliary circuits)
mechanical switching device which serves the purpose of controlling the operation of switchgear or controlgear, including signalling, electrical interlocking, etc.

Note 1 to entry: A control switch consists of one or more contact elements with a common actuating system.

[SOURCE: IEC 60050-441:2000, 441-14-46]

3.5.8
auxiliary contact
contact included in an auxiliary circuit and operated by the switching device

[SOURCE: IEC 60050-441:2000, 441-15-10, modified – delete "mechanically"]

3.5.9
control contact
contact included in a control circuit of a switching device and operated by this device

[SOURCE: IEC 60050-441:2000, 441-15-09, modified – delete "mechanical" and "mechanically"]

3.5.10
connection (bolted or the equivalent)
two or more conductors designed to ensure permanent circuit continuity when forced together by means of screws, bolts or the equivalent

3.5.11
position indicating device
part of a mechanical switching device which indicates whether it is in the open, closed, or where appropriate, earthed position

[SOURCE: IEC 60050-441:2000, 441-15-25]

3.5.12
monitoring device
device intended to observe automatically the status of an item

3.5.13
pilot switch
non-manual control switch actuated in response to specified condition of an actuating quantity

Note 1 to entry: The actuating quantity may be pressure, temperature, velocity, liquid level, elapsed time, etc.

[SOURCE: IEC 60050-441:2000, 441-14-48]

3.5.14
partition (of an assembly)
part of an assembly separating one compartment from other compartments

[SOURCE: IEC 60050-441:2000, 441-13-06]

3.5.15
actuator
part of the actuating system to which an external actuating force is applied

Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

[SOURCE: IEC 60050-441:2000, 441-15-22]

3.5.16
splice
connecting device with barrel(s) accommodating electrical conductor(s) with or without additional provision to accommodate and secure the insulation

[SOURCE: IEC 60050-581:2008, 581-24-19, modified – addition of "electrical".]

3.5.17
terminal
point of interconnection of an electric circuit element, an electric circuit or a network with other electric circuit elements, electric circuits or networks

Note 1 to entry: For an electric circuit element, the terminals are the points at which or between which the related integral quantities are defined. At each terminal, there is only one electric current from outside into the element.

Note 2 to entry: The term “terminal” has a related meaning in IEC 60050-151.

[SOURCE: IEC 60050-131:2002, 131-11-11]

3.5.18
terminal block
assembly of terminals in a housing or body of insulating material to facilitate interconnection between multiple conductors

[SOURCE: IEC 60050-581:2008, 581-26-26]

3.5.19
contactor
mechanical contactor
mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

Note 1 to entry: Contactors may be designated according to the method by which the force for closing the main contacts is provided.

[SOURCE: IEC 60050-441:2000, 441-14-33]

3.5.20
starter
combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection

Note 1 to entry: Starters may be designated according to the method by which the force for closing the main contacts is provided.

[SOURCE: IEC 60050-441:2000, 441-14-38]

3.5.21
vacuum interrupter
component being part of a switching device in which electrical contacts operate in a highly evacuated, hermetically sealed environment

3.5.22
operation counter
device indicating the number of operating cycles a mechanical switching device has accomplished

3.5.23
coil
set of series-connected turns, usually coaxial

[SOURCE: IEC 60050-151:2001, 151-13-15]

3.5.24
auxiliary and control circuits
entity of

– control and auxiliary circuits, mounted on or adjacent to the switchgear or controlgear, including circuits in central control cubicles;
– equipment for monitoring, diagnostics, etc. that is part of the auxiliary circuits of the switchgear or controlgear;
– circuits connected to the secondary terminals of instrument transformers, that are part of the switchgear or controlgear

3.5.25
subassembly (of auxiliary and control circuits)
part of auxiliary and control circuits, with regard to function or position, having its own interface and normally placed in a separate enclosure

3.5.26
interchangeable subassembly (of an auxiliary and control circuits)
subassembly which is intended to be placed in various positions within an auxiliary and control circuits, or intended to be replaced by other similar subassemblies

Note 1 to entry: An interchangeable subassembly has an accessible interface.

3.5.27
interlocking device
device which makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment

[SOURCE: IEC 60050-441:2000, 441-16-49]

3.6 Operational characteristics of switchgear and controlgear

3.6.1
dependent power operation (of a mechanical switching device)
operation by means of energy other than manual, where the completion of the operation is dependent upon the continuity of the power supply (to solenoids, electric or pneumatic motors, etc.)

[SOURCE: IEC 60050-441:2000, 441-16-14]

3.6.2
stored energy operation (of a mechanical switching device)
operation by means of energy stored in the drive mechanism itself prior to the completion of the operation and sufficient to complete it under predetermined conditions

Note 1 to entry: This kind of operation may be subdivided according to:

– the manner of storing the energy (spring, weight, etc.);
– the origin of the energy (manual, electric, etc.);
– the manner of releasing the energy (manual, electric, etc.).

[SOURCE: IEC 60050-441:2000, 441-16-15, modified – addition of "drive".]

3.6.3
independent unlatched operation
stored energy operation where energy is stored and released in one continuous operation such that the speed and force of the operation are independent of the rate of applied energy

Note 1 to entry: The energy stored for the operation may originate from the operator (manual) or a power source.

3.6.4
positively driven operation
operation which, in accordance with specified requirements, is designed to ensure that auxiliary contacts of a mechanical switching device are in the respective positions corresponding to the open or closed position of the main contacts

Note 1 to entry: A positively driven operating device is made by the association of a moving part, linked mechanically to the main contact of the primary circuit, without the use of springs, and a sensing element. In the case of mechanical auxiliary contacts, this sensing element can be simply the fixed contact, directly connected to the secondary terminal. In the case where the function is achieved electronically, the sensing element can be a static transducer (optical, magnetic, etc.) associated with a static switch, or associated with an electronic or electro-optic transmitting element.

[SOURCE: IEC 60050-441:2000, 441-16-12, modified – the Note 1 to entry has been added]

3.6.5 Terms and definitions relative to pressure (or density)

3.6.5.1
filling pressure p_{re} for insulation and/or switching
filling density ρ_{re} for insulation and/or switching
pressure (in Pa), for insulation and/or for switching, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, to which the assembly is filled before being put into service, or automatically replenished

3.6.5.2
filling pressure p_{rm} for operation
filling density ρ_{rm} for operation
pressure (in Pa), for operation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, to which the energy storage device is filled before being put into service or automatically replenished

3.6.5.3
alarm pressure p_{ae} for insulation and/or switching
alarm density ρ_{ae} for insulation and/or switching
pressure (in Pa), for insulation and/or for switching, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which a monitoring signal may be provided

3.6.5.4
alarm pressure p_{am} for operation
alarm density ρ_{am} for operation
pressure (in Pa), for operation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which a monitoring signal from the energy storage device may be provided

3.6.5.5
minimum functional pressure p_{me} for insulation and/or switching
minimum functional density ρ_{me} for insulation and/or switching
pressure (in Pa), for insulation and/or for switching, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which and above which rated characteristics of switchgear and controlgear are maintained

3.6.5.6
minimum functional pressure p_{mm} for operation
minimum functional density ρ_{mm} for operation
pressure (in Pa), for operation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which and above which rated characteristics of switchgear and controlgear are maintained and at which a replenishment of the energy storage device becomes necessary

Note 1 to entry: This pressure is often designated as interlocking or lockout pressure.

3.6.6 Terms and definitions relating to gas and vacuum tightness

3.6.6.1
controlled pressure system for gas
volume which is automatically replenished from an external compressed gas supply or internal gas source

Note 1 to entry: Examples of controlled pressure systems are air-blast circuit-breakers or pneumatic drive mechanisms.

Note 2 to entry: A volume may consist of several permanently connected gas-filled compartments.

3.6.6.2
closed pressure system for gas
volume which is replenished when needed by manual connection to an external gas source

Note 1 to entry: Example of closed pressure systems are SF_6 single-pressure circuit-breakers.

3.6.6.3
sealed pressure system
volume for which no further liquid, gas or vacuum processing is required during its expected operating duration

Note 1 to entry: Examples of sealed pressure systems are vacuum interrupters or some SF_6 circuit-breakers.

Note 2 to entry: Sealed pressure systems are completely assembled and tested in the factory.

Note 3 to entry: Expected operating duration starts when the device is sealed.

3.6.6.4
absolute leakage rate
F
amount of gas escaped by time unit

Note 1 to entry: The absolute leakage rate is usually expressed in Pa × m^3 x s^{-1}.

3.6.6.5
permissible leakage rate
F_p
maximum permissible absolute leakage rate of gas specified for a part, a component or a sub-assembly, or by using the tightness coordination chart, for an arrangement of parts, components or subassemblies connected together in one pressure system

3.6.6.6
relative leakage rate
F_{rel}
absolute leakage rate related to the total amount of gas in the system at filling pressure (or density)

Note 1 to entry: The relative leakage rate is expressed in percentage per year or per day.

3.6.6.7
time between replenishments
t_r
time elapsed between two replenishments performed manually when the pressure (density) reaches the alarm level, to compensate the leakage rate F

Note 1 to entry: This value is applicable to closed pressure systems.

3.6.6.8
number of replenishments per day
N
number of replenishments to compensate the leakage rate F

Note 1 to entry: This value is applicable to controlled pressure systems.

3.6.6.9
pressure drop
Δp
drop of pressure in a given time caused by the leakage rate F, without replenishment

3.6.6.10
tightness coordination chart
survey document supplied by the manufacturer, used when testing parts, components or sub-assemblies, to demonstrate the relationship between the tightness of a complete system and that of the parts, components and/or sub-assemblies

3.6.6.11
sniffing
action of slowly moving a leak meter sensing probe around an assembly to locate a gas leak

3.6.6.12
cumulative leakage measurement
measurement which takes into account all the leaks from a given assembly to determine the leakage rate

3.6.7 Terms and definitions relating to liquid tightness

3.6.7.1
absolute leakage rate
F_{liq}
amount of liquid escaped by time unit

Note 1 to entry: The absolute leakage rate is usually expressed in $cm^3 \times s^{-1}$.

3.6.7.2
permissible leakage rate
$F_{p(liq)}$
maximum permissible leakage rate specified by the manufacturer for a liquid pressure system

3.6.7.3
number of replenishments per day
N_{liq}
number of replenishments to compensate the leakage rate F_{liq}

3.6.7.4
pressure drop
Δp_{liq}
drop in pressure in a given time caused by the leakage rate F_{liq} without replenishment

3.7 Characteristic quantities

3.7.1
isolating distance (of a pole of a mechanical switching device)
clearance between open contacts meeting the withstand voltage requirements specified for disconnectors

[SOURCE: IEC 60050-441:2000, 441-17-35, modified – "safety" replaced by "withstand voltage".]

3.7.2
rated value
value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system

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

3.7.3
highest voltage for equipment
U_m
greatest value of phase-to-phase voltage (RMS value) for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

Note 1 to entry: Under normal service conditions specified by the relevant apparatus committee this voltage can be applied continuously to the equipment.

[SOURCE: IEC 60050-614: 2016, 614-03-01, modified – The note to entry was added]

3.7.4
supply voltage (of auxiliary and control circuits)
RMS value or, if applicable, the DC value, of the voltage existing at a given instant at a point of supply, measured over a given time interval

Note 1 to entry: If a supply voltage is specified for instance in the supply contract, then it is called “declared supply voltage”.

Note 2 to entry: The supply voltage of auxiliary and control circuits is measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors for the connection to the electricity supply.

[SOURCE: IEC 60050-614: 2016, 614-01-03, modified – add Note 2 to entry.]

3.8 Index of definitions

A – B

C

D

E

F

H– I

M

N – O

P

R

S

T – V

4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable.

5 Ratings

5.1 General

The relevant ratings for the internal arc classification are the following:

a) rated voltage (U_r);
b) rated frequency (f_r);
c) ratings of the internal arc classification (IAC).

5.2 Rated voltage (U_r)

5.2.1 General

The rated voltage (U_r), as used in this document, is the phase-to-phase RMS voltage equal to the maximum system voltage for which the equipment is designed. It indicates the maximum value of the "highest system voltage" of networks for which the equipment may be used (see 3.7.3, highest voltage for equipment U_m). The rated voltages are given in 5.2.2 and 5.2.3 below.

NOTE The term "rated maximum voltage" used in most IEEE switchgear standards has the same meaning as the term "rated voltage" as used in this document.

The rated voltage is equal to the maximum system voltage for which the equipment is designed. It indicates the maximum value of the "highest system voltage" of networks for which the equipment may be used (refer to Clause 9 of IEC 60038:2009 [6]).

NOTE It is possible that components forming part of pole-mounted switchgear and controlgear have differing values of rated voltage in accordance with their relevant standards.

5.2.2 Range I for rated voltages of 245 kV and below

Series I: 3,6 kV – 7,2 kV – 12 kV – 17,5 kV – 24 kV – 36 kV – 40,5 kV – 52 kV – 72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV.

Series II (Voltages based on the current practice in some countries, e.g. US):

4,76 kV – 8,25 kV– 15 kV (see Note 1) – 15,5 kV– 25,8 kV (see Note 2) – 27 kV – 38 kV – 48,3 kV – 72,5 kV – 123 kV–145 kV – 170 kV – 245 kV.

NOTE 1 The 15 kV rating is used in US and some other countries. It has historically been associated with metal-clad and metal-enclosed switchgear used for applications that are primarily indoors and/or outdoors where the insulation level is less than that required for outdoor overhead applications. For applications other than metal-clad or metal-enclosed switchgear, the 15,5 kV rating is preferred.

NOTE 2 The 25,8 kV, still used in IEEE C37.04 [21] as a circuit breaker rating and in some other countries, has been replaced by the 27 kV rating in most relevant equipment standards. For new applications and designs, the 27 kV rating is preferred.

5.2.3 Range II for rated voltages above 245 kV

300 kV – 362 kV – 420 kV – 550 kV – 800 kV – 1 100 kV – 1 200 kV.

5.3 Rated insulation level (U_d, U_p, U_s)

Not applicable.

5.4 Rated frequency (f_r)

The preferred values of the rated frequency are 16,7 Hz, 25 Hz, 50 Hz and 60 Hz.

5.5 Rated continuous current (I_r)

Not applicable.

5.6 Rated short-time withstand current (I_k)

Not applicable.

5.7 Rated peak withstand current (I_p)

Not applicable.

5.8 Rated duration of short-circuit (t_k)

Not applicable.

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

Not applicable.

5.10 Rated supply frequency of auxiliary and control circuits

Not applicable.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Not applicable.

5.101 Ratings of the internal arc classification (IAC)

5.101.1 General

An IAC classified pole-mounted switchgear and controlgear shall have the following ratings: rated approach distance, arc fault currents and arc fault durations.

5.101.2 Rated approach distance (D_{AP})

The rated approach distance shall be stated by the manufacturer (refer to Figure 2).

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

The value of rated arc fault currents should be selected from the R 10 series specified in IEC 60059 [7].

Two ratings of the arc fault currents are recognised:

a) three-phase and phase-to-phase arc fault current (I_A), when applicable;

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

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

NOTE 1 The rationale for this 87 % is the arc fault test with 2-phase ignition; refer to 7.101.7.2.

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

In the case where all high-voltage compartments are only designed for single-phase-to-earth arc faults, instead of I_A rating, the I_{Ae} rating shall be assigned (refer to 7.101.7.2).

NOTE 2 Information about the relationship between type of neutral earthing and the single-phase-to-earth arc fault current is provided in 9.101.6.

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

Recommended values for the arc fault duration (t_A, t_{Ae}) are 0,1 s, 0,5 s and 1 s.

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

Not applicable.

6.2 Requirements for gases in switchgear and controlgear

Not applicable.

6.3 Earthing of switchgear and controlgear

Not applicable.

6.4 Auxiliary and control equipment and circuits

Not applicable.

6.5 Dependent power operation

Not applicable.

6.6 Stored energy operation

Not applicable.

6.7 Independent unlatched operation (independent manual or power operation)

Not applicable.

6.8 Manually operated actuators

Not applicable.

6.9 Operation of releases

Not applicable.

6.10 Pressure/level indication

Not applicable.

6.11 Nameplates

6.11.1 General

Not applicable.

6.11.2 Application

Table 9 shall be used where applicable if the product standard does not provide more specific information.

In particular, the terminology, abbreviations and units given in the table shall be used as appropriate. Annex G (informative) provides an extended list including non-rated values. The following recommendations should be considered as appropriate:

a) the type and mass of insulating fluid should be noted either on a nameplate or on a label placed in a visible location;

b) it should be stated whether pressures are absolute or relative values;

c) switchgear and controlgear installed outdoors or in high humidity should have nameplates and have methods of attachment that are weather-proof and corrosion-proof;

d) switchgear and controlgear that consist of several poles with individual drive mechanisms should be provided with a nameplate for each pole;

e) for an operating device combined with a switchgear device, it may be sufficient to use only one combined nameplate;

f) nameplates should be visible in the position of normal service and installation;

g) technical characteristics on nameplates and/or in documents which are common to several kinds of high-voltage switchgear and controlgear should be represented by the same symbols;

h) since other characteristics (such as type of gas or temperature limits) are specialized, they shall be represented by the symbols which are used in the relevant standards.

Table 1 – Nameplate information

Not applicable.

Pole-mounted switchgear and controlgear, with a rated internal arc classification shall include in the nameplate the additional IAC information in accordance with Table 1.

Table 2 – Nameplate information

	Abbreviation	Unit	**	Condition: Marking only required if
(1)	(2)	(3)	(4)	(5)
Internal arc classification	IAC		X	
Rated approach distance	D_{AP}	m	X	
Arc fault current and duration	I_A, t_A	kA, s	Y	Three-phase test or phase-to-phase test are applicable
Single-phase-to-earth arc fault current and duration	I_{Ae}, t_{Ae}	kA, s	Y	A single-phase test is applicable or I_{Ae} differs from 87 % of I_A
Fitted with arc mitigation device			Y	Arc mitigation device fitted and not disabled during testing
(**) X : the marking of these values is mandatory Y : conditions for marking of these values are given in column (5)				
NOTE If there is an abbreviation in column (2) it can be used instead of the terms in column (1).				

6.12 Locking devices

Not applicable.

6.13 Position indication

Not applicable.

6.14 Degrees of protection provided by enclosures

Not applicable.

6.15 Creepage distances for outdoor insulators

Not applicable.

6.16 Gas and vacuum tightness

Not applicable.

6.17 Tightness for liquid systems

Not applicable.

6.18 Fire hazard (flammability)

Not applicable.

6.19 Electromagnetic compatibility (EMC)

Not applicable.

6.20 X-ray emission

Not applicable.

6.21 Corrosion

Not applicable.

6.22 Filling levels for insulation, switching and/or operation

Not applicable.

6.101 Internal arc fault

Pole-mounted switchgear and controlgear, in principle, are designed and manufactured, to prevent the occurrence of internal arc faults.

However, the switchgear and controlgear shall be designed to give a defined level of protection of persons in the event of an internal arc, when the switchgear and controlgear is in normal operating condition.

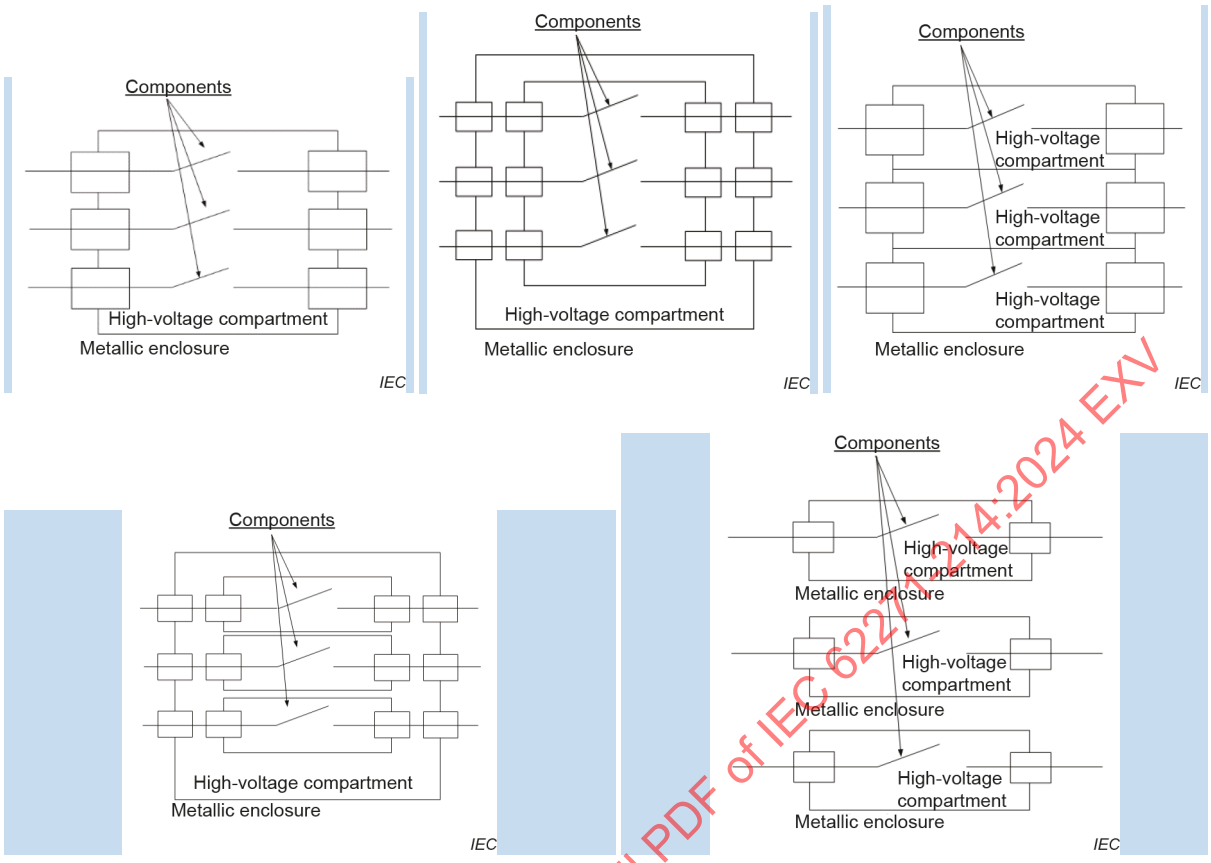
The designation shall be included in the nameplate (refer to 6.11).

Some examples for internal arc classification are given in 7.101.7.2.5.

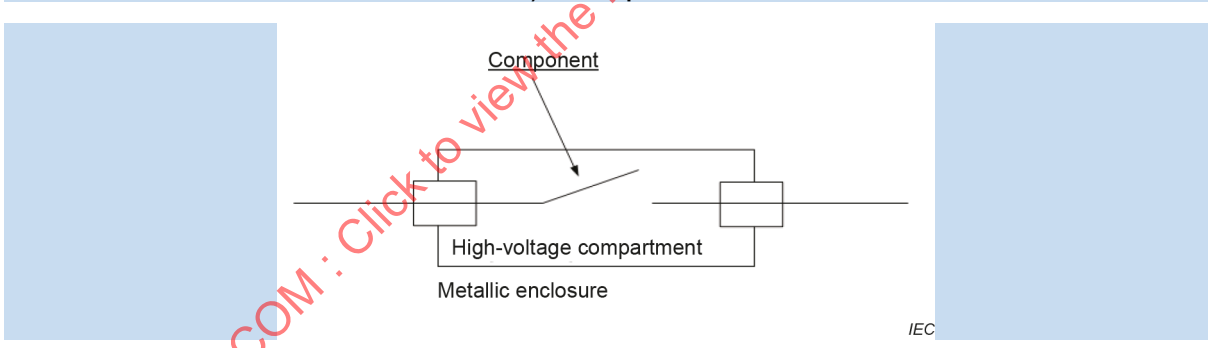
6.102 Enclosure

The enclosure is designed for withstanding the mechanical, electrical, thermal and environmental stresses likely to be encountered in normal operating condition and under conditions of internal arc fault.

Figure 1 shows examples of different arrangements of components in high voltage compartment(s) within an enclosure.



a) three-phase



b) single-phase

Figure 1 – Examples of enclosures and compartment(s) in different arrangements

7 Type tests

7.1 General

7.1.1 Basics

The type tests are for the purpose of proving the ratings and characteristics of switchgear and controlgear, their operating devices and their auxiliary equipment. Each individual type test or type test sequence shall be made on test objects as defined in 3.2.1, in the condition as required for service (filled with the specified types and quantities of liquid or gas), with their operating devices and auxiliary equipment, all of which in principle shall be in, or restored to, a new and clean condition at the beginning of each type test or type test sequence.

Reconditioning during individual type tests or test sequence may be allowed, according to the relevant IEC product standard. The manufacturer shall provide a statement to the testing laboratory of those parts that may be renewed during the tests.

Tolerances on test quantities are listed in Table E.1.

Information regarding the extension of validity of type tests is given in Annex J (informative).

The type test is performed to verify the internal arc ratings and characteristics of pole-mounted switchgear and controlgear.

7.1.2 Information for identification of test objects

The manufacturer shall submit to the testing laboratory, drawings and other data containing sufficient information to unambiguously identify by type the essential details and parts of the switchgear and controlgear presented for test. A summary list of the drawings and data schedules shall be supplied by the manufacturer and shall be uniquely referenced and shall contain a statement to the effect that the manufacturer guarantees that the drawings or data schedules listed are the correct version and truly represent the switchgear and controlgear to be tested.

The testing laboratory shall check that drawings and data sheets adequately represent the essential details and parts of the test object, but is not responsible for the accuracy of the detailed information.

Particular drawings or data required to be submitted by the manufacturer to the test laboratory for identification of essential parts of test object are specified in Annex A.

7.1.3 Information to be included in type-test reports

The results of all type-tests shall be recorded in type-test reports containing sufficient data to prove compliance with the ratings and the test clauses of the relevant standards and sufficient information shall be included so that the essential parts of the test object can be identified. In particular, the following information shall be included:

– the manufacturer;
– the type designation and the serial number of the test object;
– the rated characteristics of the test object as specified in the relevant IEC standard;
– the general description of the test object, including number of poles;
– the manufacturer, type, serial numbers and ratings of essential parts, where applicable (for example, drive mechanisms, interrupters, shunt impedances);
– the general details of the supporting structure of the switching device or enclosed switchgear of which the switching device forms an integral part;
– the details of the operating-mechanism and devices employed during tests, where applicable;
– photographs to illustrate the condition of the test object before and after test;
– sufficient outline drawings and data schedules to represent the test object;
– the reference numbers of all drawings including revision number submitted to identify the essential parts of the test object;
– a statement that the test object complies with the drawings submitted;
– details of the testing arrangements (including diagram of test circuit);
– statements of the behaviour of the test object during tests, its condition after tests and any parts renewed or reconditioned during the tests;

– in case of breaking operations with some specific technologies, NSDDs may occur during the recovery voltage period. Their number is of no significance to interpreting the performance of the device under test. They shall be reported in the test report only in order to differentiate them from restrikes;

– records of the test quantities during each test or test duty, as specified in the relevant IEC standard;

– the location, laboratory name where the tests were conducted and date of test.

The results shall be recorded in type-test reports containing sufficient data to prove compliance with the test clauses of this document for the test(s) conducted. Sufficient information shall be included so that the essential parts of the test object can be identified. In particular, the following information shall be included:

– manufacturer;

– type designation and unique identifier for the test object;

– rated characteristics of the test object;

– photographs to illustrate the condition of the test object before and after test;

– sufficient outline drawings and data schedules to represent the test object;

– the reference numbers of all drawings including revision number submitted to identify the essential parts of the test object;

– details of the testing arrangement (including diagram of test circuit);

– statements of the behaviour of the test object during test and its condition after test;

– description of the test object with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief device(s) and the method of fixing the test object to the pole(s), including the pole characteristics;

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

– drawings of test arrangement (test object, source side connection point, and mounting frame of indicators, pole dimensions) and any other relevant installation conditions; applied voltage and frequency;

  - IAC designation validated by test;
  - include use of fuse protection if used;
  - include the use of arc mitigation device if used;

– for the prospective and/or test current (refer to 7.101.6.3):

  a) RMS value of the AC component during:

     - the first three half-cycles;
     - the last three half-cycles;

  b) highest peak value (actual and/or prospective);

  c) average RMS value of the AC component over the actual duration of the test;

  d) duration of arc fault current;

  e) 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 7.101.8;

– other relevant remarks.

7.2 Dielectric tests

Not applicable.

7.3 Radio interference voltage (RIV) test

Not applicable.

7.4 Resistance measurement

Not applicable.

7.5 Continuous current tests

Not applicable.

7.6 Short-time withstand current and peak withstand current tests

Not applicable.

7.7 Verification of the protection

Not applicable.

7.8 Tightness tests

Not applicable.

7.9 Electromagnetic compatibility tests (EMC)

Not applicable.

7.10 Additional tests on auxiliary and control circuits

Not applicable.

7.11 X-radiation test for vacuum interrupters

Not applicable.

7.101 Internal arc type test

7.101.1 General

The test is applicable to pole-mounted switchgear and controlgear for which internal arc classification is assigned, covering the event of an arc fault within the enclosure(s) or within components having housings which form part of the enclosure in normal operating condition. 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, and for the effects of ejected hot gases and glowing particles on the persons situated beneath the apparatus under test.The tests are not intended to cover e.g.:

– the influences of an internal arc between compartments;
– the effect of an arc on the external connections outside the enclosure;
– 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 pole-mounted switchgear and controlgear.

7.101.2 Test conditions

The test shall be carried out with the switchgear and controlgear in normal operating condition. This means the position of high-voltage switching devices is set according to

7.101.7.1.4. All other equipment, for example measuring instruments and monitoring equipment shall be in the position as it is in normal operating condition.

Pole-mounted switchgear and controlgear which are protected by type-tested current-limiting fuses, integrated inside the switchgear and controlgear, 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 tests shall be performed at the rated voltage of the equipment. The tested switchgear and controlgear will be designated as 'fuse-protected'. The specific fuse, including manufacturer, part number, and ratings, used for protection shall be specified in the instructions manual.

Application of suitable current-limiting fuses in combination with switching devices can limit the short-circuit current and minimize the fault duration. It is well documented that the arc energy transferred during such tests is not predictable by I^2t. In the case of current-limiting fuses, the maximum arc energy may occur at current levels below the maximum interrupting rating. Further, the effects of using current-limiting devices that employ pyrotechnic means to commutate current to a current-limiting fuse shall be considered when evaluating designs utilizing such devices.

Any device (for example, protection relay) that may automatically trip the circuit before the end of the prospective duration of the test shall be made inoperative during the test. If pole-mounted switchgear and controlgear is equipped with devices intended to limit the duration of the arc itself by other means (for example, by transferring the current to a metallic short circuit), they shall be made inoperative during the test. If these devices are an integral part of the design of the high-voltage compartment or assembly which prevents them being made inoperative without modification of the construction, the relevant high-voltage compartment of the switchgear and controlgear may be tested with the device operative; but this switchgear and controlgear shall be qualified according to the actual duration of the arc. The test current shall be maintained for the rated arc fault duration of the switchgear and controlgear.

NOTE Because in general arc limiting devices are out of the scope of this document and if the switchgear and controlgear has previously been tested with the limiting device made inoperative, an additional test can be performed to demonstrate the behaviour of this arc limiting device.

7.101.3 Arrangement of the equipment

The test arrangement for pole-mounted switchgear and controlgear shall be configured as indicated in Figure 2.

Dimensions in millimetres

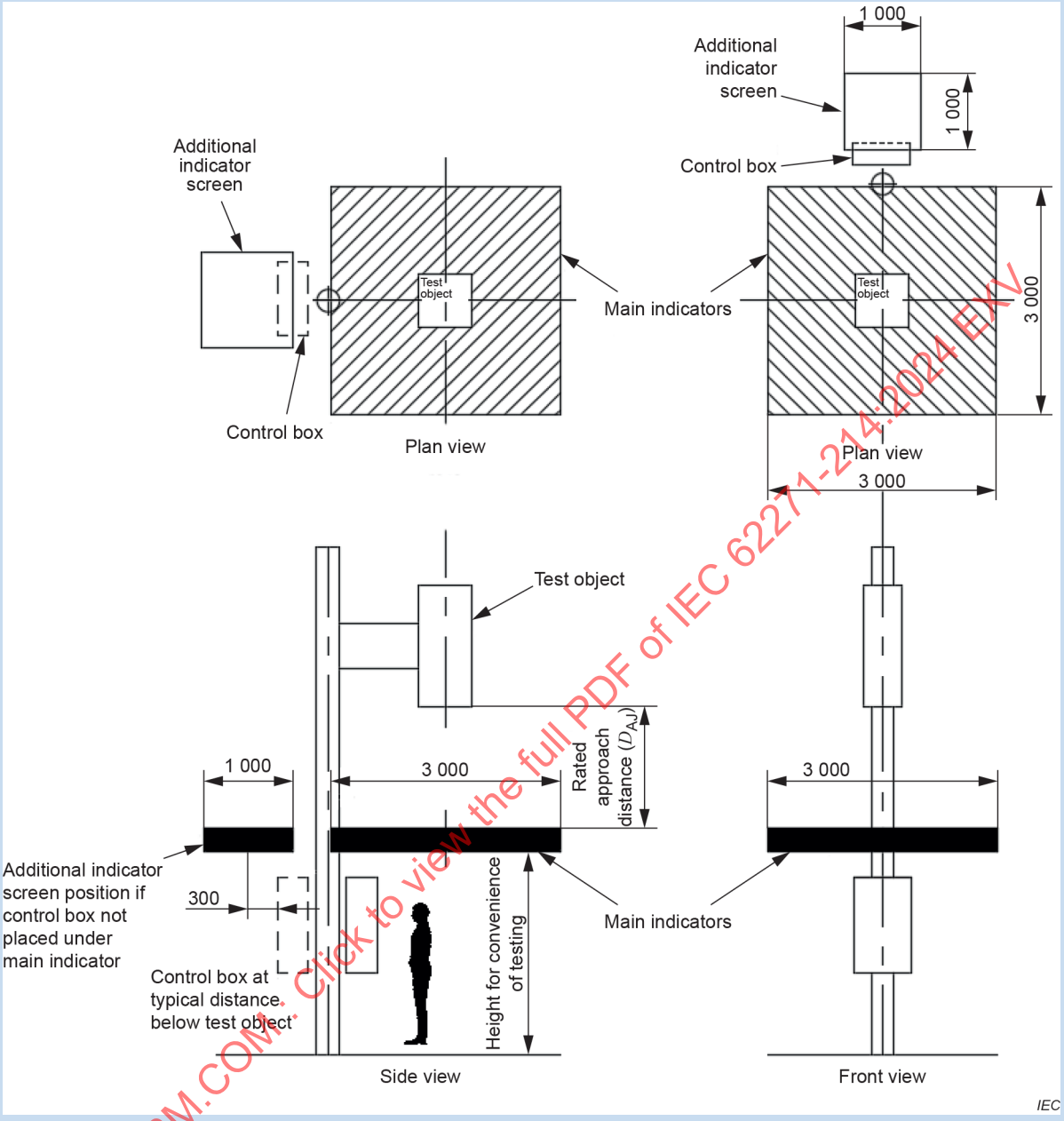


Figure 2 – Test arrangement for pole-mounted switchgear and controlgear

The equipment shall be arranged as follows:

– 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;

– the test object shall be mounted on a pole. If there is a control box and/or electrical/mechanical linkages to the base of the pole, these shall be fitted at a distance below the test object typical of a service installation. The test object shall be at a convenient height allowing for the indicators as specified in 7.101.5, and for the control box and/or electrical/mechanical linkages (if applicable);

– In the case the control box is not fully covered by the main indicators the test shall include a 1 000 mm × 1 000 mm indicator screen above control box, refer to Figure 2;

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

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

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

– for environmental reasons, it is recommended to replace SF_6 with air at the filling pressure (±10 %).

NOTE 1 Test results with air instead of SF_6 are considered to be representative.

NOTE 2 Nitrogen at the filling pressure (±10 %) is also considered a substitute for SF_6 [9].

NOTE 3 It is assumed that the physical dimensions of the test laboratory are large enough to prevent hot gas reflection towards the indicators.

7.101.4 Indicators (for assessing the thermal effects of the gases)

7.101.4.1 General

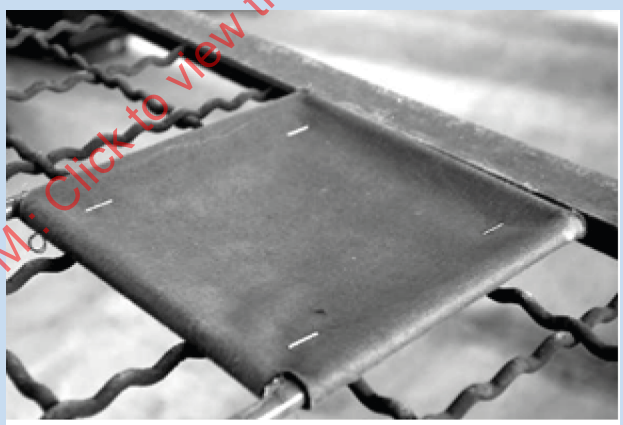
Indicators are pieces of black cotton cloth so arranged that their cut edges do not point toward the test object.

Black cotton-interlining lawn (approximately 40 g/m^2) shall be used for indicators.

NOTE Cotton-interlining lawn (approximately 40 g/m^2) is considered to represent light summer wear of the general public.

Care shall be taken that glowing particles do not accumulate. This is achieved if the indicators are mounted without a frame (refer to Figure 3).

The indicator dimensions shall be 150 mm × 150 mm ($^{+15}_{0}$ mm).



IEC

Figure 3 – Horizontal indicator

Figure 3 provides an indication of a typical arrangement of a horizontal indicator.

7.101.5 Arrangement of indicators

Indicators shall be arranged horizontally, at the rated approach distance (±50 mm) below the lowest point of the test object. The indicators shall cover the whole area of a 3 m × 3 m square frame centered about the test object. They shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area (refer to Figure 2 and Figure 3).

The indicators may be located at any convenient height above the ground allowing for the control box and/or electrical/mechanical linkages if applicable. If the control box's location is not fully located under the 3 000 mm × 3 000 mm indicator area (refer to Figure 2), then an

additional indicator screen 1 000 mm × 1 000 mm shall be positioned above the mounting position of the control box. The additional screen shall be in the same plane as the 3 000 mm × 3 000 mm indicator screen and centered as detailed in Figure 2.

NOTE 1 The additional screen is used to determine if the operators standing position, when in front of the control box, is adequately protected from hot gases and flame.

NOTE 2 This test covers the verification of the protection of both authorized personnel and general public beneath the apparatus.

7.101.6 Test parameters

7.101.6.1 General

A test performed at a given voltage, current and duration is generally valid for all lower values of current, voltage and duration.

7.101.6.2 Voltage

The test shall be performed at any suitable voltage up to and including the rated voltage U_r. If a voltage lower than U_r is chosen, the following conditions shall be met.

a) the current during the test as computed by a digital recording device complies with current requirements of 7.101.6.3.1;

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 not 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 7.101.6.3.1 in the relevant phase.

7.101.6.3 Current

7.101.6.3.1 AC component

The test current shall be set within a ±5 % tolerance of the rated arc fault current (I_A, 87 % I_A or I_{Ae}) as appropriate. If the applied voltage is equal to U_r, this tolerance applies 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^2t) 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.

NOTE Information about the relationship between type of neutral earthing and the single-phase-to-earth arc fault current is provided in 9.101.6.

7.101.6.3.2 Peak current

The instant of closing for a three-phase test 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 U_r, 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 60 Hz) the RMS value of the AC component defined in 7.101.6.3.1 with a tolerance of $^{+5}_{0}$ %.

If the voltage is lower than U_r, the peak value of the prospective current is irrelevant, but the peak value of the short-circuit current for the switchgear and controlgear under test shall not drop below 90 % of the rated peak value.

For higher DC time constants than the standard defined 45 ms of the feeding network, 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.

In case of two-phase initiation of the arc, or single-phase-to-earth the instant of closing shall be chosen to provide the maximum possible DC component.

7.101.6.3.3 Frequency

Tests performed at 50 Hz are also applicable for 60 Hz and vice a versa. At a rated frequency of 50 Hz or 60 Hz, the frequency at the beginning 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 %. The peak factor requirement of subclause 7.101.6.3.2 shall be met as appropriate.

7.101.7 Test procedure

7.101.7.1 Supply circuit

7.101.7.1.1 Three-phase tests

The supply circuit shall be three-phase and all three-phases of the switchgear and controlgear shall be energised. The neutral point of the supply circuit may be either isolated, solidly earthed or earthed through an impedance. Any of these test configurations cover all in service neutral arrangements.

7.101.7.1.2 Single-phase tests

One terminal of the supply circuit shall be connected to the earthing point provided on the switchgear and controlgear, the other to the phase under test.

NOTE Single-phase compartments and single-phase enclosures will only have the one phase under test as defined in Table 2.

In the case of three-phase switchgear and controlgear or single-phase switchgear and controlgear intended to be used in a three-phase network, the two remaining phases of the test object, shall be energised at $U_r/\sqrt{3}$, which may be supplied from a separate voltage source and need not be synchronised. The separate source(s) may be low power and are not intended to supply any significant short-circuit current in case of ignition. If a separate source is used, the remaining two phases can be energised from the same single-phase voltage source. If either of the remaining phases ignites or the voltages collapse, the test shall be repeated as a three-phase internal arc test.

7.101.7.1.3 Phase-to-phase tests

Two phases of the three-phase supply circuit shall be connected to the two adjacent phases of the test object. 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. The one remaining phase of the test object, shall be energised at $U_r/\sqrt{3}$, which may be supplied from a separate voltage source and need not be synchronised. The separate source(s) may be low power and are not intended to supply any significant short-circuit current in case of ignition. If the one remaining phase ignites or the voltage collapses, the test shall be repeated as a three-phase internal arc test.

7.101.7.1.4 Test supply connection direction

The test supply connection direction shall be as follows:

– from the supply connection terminals, through the main switching device with this device in the closed position;

– for an enclosure with several main circuit components inside: supply through one available set of connection terminals, with all switching devices in closed position, except for earthing switches, if any, which shall remain in open position.

7.101.7.2 Arc initiation

7.101.7.2.1 General

The arc shall be initiated by means of a copper wire of about 0,5 mm in diameter.

The point of initiation shall be located at the furthest point, downstream in the current path from the supply, within the high-voltage compartment under test. If the main circuit of the high-voltage compartment under test includes current limiting devices (e.g. fuses), the point of initiation shall be chosen upstream from these limiting devices.

In the case of non-symmetrical designs, the most onerous internal arc initiation should be determined, with respect to arc energy and burn through.

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 2, according to the construction of the enclosure under test.

NOTE Refer to Figure 4 and examples in 7.101.7.2.5.

Inside the enclosure 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 or insulating partitions;

b) when a) is not applicable, by perforation or partial removal of solid insulation from the internal conductors.

7.101.7.2.2 Three-phase arc initiation

The arc shall be initiated between all the phases under test.

7.101.7.2.3 Single-phase arc initiation

In the case of single-phase-to-earth ignition, the arc shall be initiated between the phase and closest earth (single-phase). In the case of a three-phase switchgear and controlgear the arc shall be initiated between the middle phase and closest earth.

For single-phase high-voltage compartments without any adjacent earthed metallic parts, a path for the arc initiating fuse wire shall be created to the closest earthed metallic part.

7.101.7.2.4 Phase-to-phase arc initiation

In the case of a phase-to-phase ignition, the arc shall be initiated between the middle phase and one of the adjacent phases (phase-to-phase). The manufacturer may choose to perform a three-phase arc initiation test with any three-phase enclosure construction in place of the specified test in Table 2.

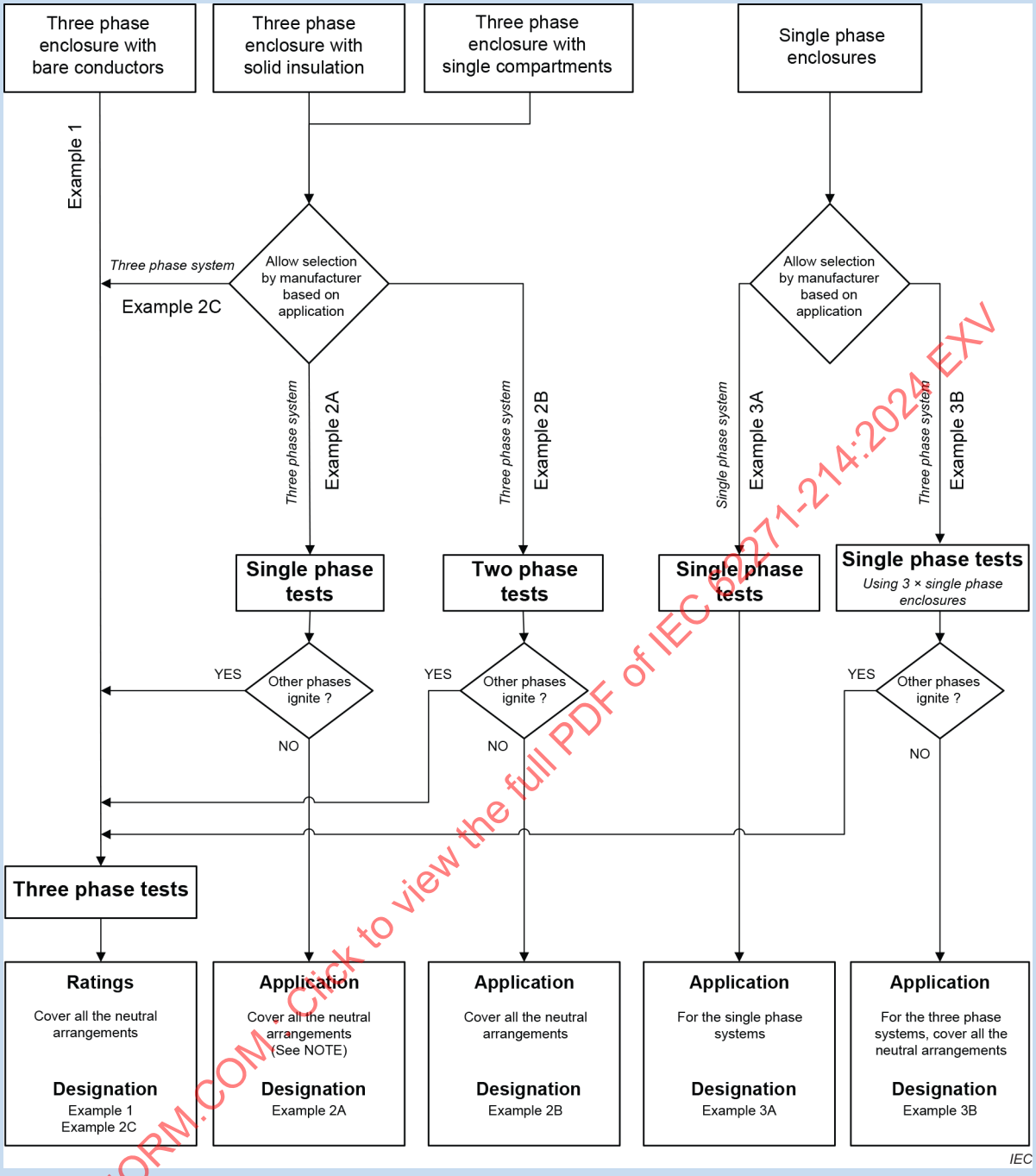
Table 3 – Parameters for internal arc fault test according to enclosure and compartment construction

		Test current	Number of phases/earth for arc initiation	Action if other phase affected
Three-phase enclosures:	With bare conductors	I_A	Three-phase	N/A
	Conductors with solid insulation	87 % I_A	Two	Repeat as three-phase test
		I_{Ae}	One phase and earth	
Single-phase compartments inside three-phase enclosure:		87 % I_A	Two	Repeat as three-phase test
		I_{Ae}	One phase and earth	
Single-phase enclosure (s):		I_{Ae}	One phase and earth	Repeat as three-phase test if single-phase enclosures are tested in a three-phase configuration

NOTE More details about arc initiation according the construction can be found in 7.101.7.2.5.

7.101.7.2.5 Arc initiation according to different construction types

Table 2 provides the parameters for an internal arc fault test according to enclosure and compartment construction. To further clarify the different test methods, refer to Figure 4 and examples in this subclause.



NOTE For systems with an isolated neutral, in the unlikely occurance of a double earth fault within the switchgear and controlgear (two phases fail to earth), then fault levels up to 87 % of the three-phase rated current might occur, and as such, a phase-to-phase fault might be a preferred option taken by the manufacturer.

Figure 4 – Flow-chart for the choice of arc initiation depending on the construction

a) Example 1: A pole-mounted switchgear and controlgear, with bare conductors, tested for a three-phase fault current (RMS) of 12,5 kA, for 0,5 s, intended to be installed on a pole, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s;

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network;

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

b) Example 2: For a three-phase enclosure with solid insulated conductors with the three-phase switchgear and controlgear intended to be suitable for a 12,5 kA 3 phase network (An IAC rating of 12,5 kA for 0,5 s) the manufacturer may choose either a phase-to-phase test or a phase-to-earth test as indicated in the following:

NOTE In this example there is only one three-phase compartment/enclosure, so no other 3 phase tests will be performed.

Example 2A: Manufacturer chooses to perform a phase-to-earth test and ensure it is suitable for all Neutral earth networks by testing with 100 % of the three-phase rated arc fault current: Test performed on a three-phase enclosure with conductors with solid insulation.

IAC;

Arc fault current 12,5 kA assessed with a phase-to-earth test (100 % of the rated single-phase-to-earth arc fault current);

Arc fault duration 0,5 s.

Second and third phase energized during the tests but not affected. In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

Designation: IAC 12,5 kA, 0,5 s (I_{Ae} = 12,5 kA).

Example 2B: Instead manufacturer chooses to perform a phase-to-phase test on a three-phase enclosure with conductors with solid insulation.

IAC;

Arc fault current 10,875 kA assessed with a phase-to-phase test;

Arc fault duration 0,5 s.

Third phase energized during the tests, but not affected.

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

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

Example 2C: The manufacturer chooses to perform a three-phase test independent of the type of three-phase switch conductor system. A pole-mounted switchgear and controlgear, tested for a three-phase fault current (RMS) of 12,5 kA, for 0,5 s, intended to be installed on a pole, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

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

c) Example 3:

Example 3A: A single-phase enclosure pole-mounted switchgear and controlgear tested for a phase-to-earth fault current (RMS) of 12,5 kA, for 0,5 s, in a single-phase system, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

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

A single-phase enclosure pole-mounted switchgear and controlgear tested in a single-phase system shall not be IAC classified for a three-phase system.

Example 3B**:** Three independent single-phase pole-mounted switchgear and controlgear enclosures tested for a phase-to-earth fault current (RMS) of 12,5 kA, for 0,5 s, in a three-phase system is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

Designation: IAC 12,5 kA, 0,5 s (I_{Ae} = 12,5 kA).

7.101.8 Criteria to pass the test

IAC designation is demonstrated for the pole-mounted switchgear and controlgear if the following criteria are met:

a) Criterion No. 1

– No fragmentation of the enclosure occurs.

– No ejection of fragments or of other parts of the switchgear of an individual mass of 60 g or more, occur.

Deformations are accepted.

The switchgear and controlgear does not need to comply with its IP code after the test.

b) Criterion No. 2

Arcing does not cause holes in the enclosure under test. Holes in the enclosure which are created after the duration of the test by other effects than burning through, are disregarded.

The inclusion of a pressure relief vent and its operation is permitted and is not deemed as a structural failure; however, any ejected parts due to its operation shall comply with the 60 g limit for ejected parts.

c) Criterion No. 3

Indicators do not ignite during the test and within 1 s after the current duration. If indicators have been ignited 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 or burning liquids, 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 burning paint or stickers are also excluded.

d) Criterion No. 4

The switchgear and controlgear 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. To check the continuity, verify by testing with 30 A (DC) to the earthing point provided. The voltage drop shall be lower than 3 V.

7.101.9 Transferability of the test results

The validity of the results of a test carried out in a tested enclosure of a particular design of pole-mounted switchgear and controlgear can be extended to another test enclosure provided that the original test was more onerous and this other test enclosure can be considered as similar to the tested unit in the following aspects:

– mounting height of test enclosure with respect to the indicator positions;
– structure and strength of the enclosure;
– performance of the pressure relief device, if any;
– insulation system;
– physical influences (pressure rise, gas flow and thermal effects).

NOTE IEC TR 62271-307[3] can be used as a reference.

8 Routine tests

Not applicable.

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

9.1 General

Pole-mounted switchgear and controlgear have been constructed in various forms that have evolved with changing technologies and functional requirements. The selection of pole-mounted switchgear and controlgear essentially involves an identification of the functional requirements for the service installation.

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

9.2 Selection of rated values

Not applicable.

9.3 Cable-interface considerations

Not applicable.

9.4 Continuous or temporary overload due to changed service conditions

Not applicable.

9.5 Environmental aspects

Not applicable.

9.101 Internal arc fault

9.101.1 General

If the switchgear and controlgear is installed, operated and maintained in accordance with the instructions of the manufacturer, there should be low probability that an internal arc occurs, but it cannot be completely disregarded. Failure within the enclosure of pole-mounted switchgear and controlgear due either to a defect or exceptional operating conditions or maloperation can initiate an internal arc, which constitutes a hazard, if persons are present.

When selecting pole-mounted switchgear and controlgear, 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, risk is the combination of the probability of occurrence of harm and the severity of the harm. (Refer to Clause 5 of ISO/IEC Guide 51:2014 on the concept of safety.[4])

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 [4]. This procedure is based on the assumption that the user has a role to play in the risk reduction.

9.101.2 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 3 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 applicable preventive measures to the installation, commissioning, operation and maintenance.

Table 4 – 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)
Connections (Inside the enclosure)	Inadequate design	Selection of adequate dimensions Use of appropriate materials
	Faulty assembly	Checking of workmanship and/or dielectric test on site.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of fluid levels, where applicable
Disconnectors Switches Earthing switches	Maloperation	Interlocks. 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
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 for example, protection cover, low-voltage fuses
Circuit-breakers	Insufficient maintenance	Regular programmed maintenance Instructions to personnel
All locations	Error by personnel	Limitation of access by compartmentalisation. 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. Use of sealed compartments
	Overvoltages	Surge protection. Adequate insulation co-ordination. Dielectric tests on site

9.101.3 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 can be adopted to provide protection to persons in case of an internal arc. These measures are aimed to limit the external consequences of such events.

Following are some examples of these measures:

– rapid fault clearance times initiated by detectors sensitive to light, pressure or heat;
– application of suitable fuses in combination with switching devices to limit the let-through current and fault duration;
– fast elimination of arc by diverting it to metallic short circuit by means of fast-sensing and fast-closing devices;
– remote operation instead of operation at the base of the switchgear and controlgear;
– pressure-relief device.

9.101.4 Considerations for the selection and installation

The user shall make a selection, taking into account the characteristics of the network, operating procedures and service conditions.

As a guide for the selection of the adequate switchgear and controlgear with respect to internal arcs, the following criteria can be used:

– where the risk is considered negligible, IAC designated switchgear and controlgear is not necessary;

– where the risk is considered to be relevant, IAC designated switchgear and controlgear 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 protection of persons in case of an internal arc is not only a matter of design and IAC designation of the switchgear and controlgear but depends also on the installation conditions. Internal arc faults inside pole-mounted switchgear and controlgear 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 can produce hot decomposition products, either gaseous or vaporous, which can be discharged to the outside of the enclosure. Therefore, appropriate measures should be considered for the installation site.

For pole-mounted switchgear and controlgear, the minimum installation height of the enclosure of the high-voltage is based on the rated approach distance declared by the manufacturer plus 2 m.

9.101.5 Internal arc test

The internal arc test is intended to verify the effectiveness of the design in protecting persons in case of an internal arc, during normal operating condition. The test does not assess the behaviour of the switchgear and controlgear 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 applicable to pole-mounted switchgear and controlgear, to which an Internal Arc Classification is to be assigned.

NOTE 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 what arc duration is permissible with a lower test current.

9.101.6 IAC designation

IAC designation indicates a tested level of protection of persons under normal operating condition as stated in 7.101.2. It is concerned with personnel protection under these conditions; it is not concerned with personnel protection under maintenance conditions nor with service continuity.

The pole-mounted switchgear and controlgear will be designated as follows.

– General: designation IAC (acronym for Internal Arc Classification).

– Rated values: arc fault current in kiloamperes (kA), and duration in seconds (s) (according to 7.101.6). Single-phase values can be assigned to switchgear and controlgear, having one or more high-voltage compartments where its construction will prevent the arc from

becoming multiphase, as demonstrated during the internal arc test. The relationship between neutral earthing and single-phase-to-earth arc fault current is given in Table 4. 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 can accept a lower value, depending on the neutral earthing.

Table 5 – 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 switchgear and controlgear have a very low probability. Therefore, this condition could not be applicable and the user can specify a reduced single-phase-to-earth arc fault current rating. NOTE 3 Resonant earthed (neutral) systems are covered in this table by the term "isolated neutral".	

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

10.1 General

When enquiring about or ordering an installation of IAC specified pole-mounted switchgear and controlgear the IAC pole-mounted designation, rated approach distance, arc fault currents and duration should be included.

10.2 Information with enquiries and orders

Not applicable.

10.3 Information with tenders

Not applicable.

11 Transport, storage, installation, operating instructions and maintenance

11.1 General

It is essential that the transport, storage and installation of switchgear and controlgear, as well as their operation and maintenance in service, be performed in accordance with instructions given by the manufacturer.

11.2 Conditions during transport, storage and installation

A special agreement should be made between manufacturer and user if the service conditions of temperature and humidity defined in the order cannot be guaranteed during transport, storage and installation. Special precautions may be essential for the protection of insulation during transport, storage and installation, and prior to energizing, to prevent moisture absorption due, for instance, to rain, snow or condensation. Vibrations during transport shall be considered. Appropriate instructions should be provided by the manufacturer.

11.3 Installation

11.3.1 General

For IAC classified switchgear and controlgear, guidance on safe installation conditions for the case of an internal arc should be provided. The hazards of the actual installation condition should be assessed with respect to installation conditions validated during the internal arc classification (refer to 7.101). However, if the purchaser (user) considers that the risk is not relevant, the switchgear and controlgear can be installed without the restrictions indicated by the manufacturer. The minimum installation height is the declared rated approach distance plus 2 m.

11.3.2 Unpacking and lifting

Not applicable.

11.3.3 Assembly

Not applicable.

11.3.4 Mounting

Not applicable.

11.3.5 Connections

Not applicable.

11.3.6 Information about gas and gas mixtures for controlled and closed pressure systems

Not applicable.

11.3.7 Final installation inspection

Not applicable.

11.3.8 Basic input data by the user

Not applicable.

11.3.9 Basic input data by the manufacturer

Not applicable.

11.4 Operating instructions

Not applicable.

11.5 Maintenance

Not applicable.

11.101 Maintenance

Where necessary, the manufacturer shall provide guidance on any maintenance requirements in order to maintain the integrity of the IAC designation over the life of the product. Refer to the sections of Table 3 as examples where maintenance can be considered over the life of the switchgear and controlgear.

12 Safety

12.1 General

As far as the protection of persons is concerned, the correct performance of the pole-mounted switchgear and controlgear in the event of an internal arc is not only a matter of design of the equipment itself, but also of the installation conditions, operating procedure and if applicable maintenance procedures, for instance, see 9.101.

12.2 Precautions by manufacturers

Not applicable.

12.3 Precautions by users

Not applicable.

13 Influence of the product on the environment

The manufacturer shall be prepared to provide on request, relevant information about the environmental impact of the switchgear and controlgear. The manufacturer shall give guidance on request, concerning disassembly and end-of-life procedures for the different materials and components of the equipment and indicate recycling suitability.

Annex A
(normative)

Identification of test objects

A.1 General

For identification of a test object, the following topics shall be covered.

A.2 Data

– Manufacturer's name;
– Type designation, ratings and unique identifier of test object;
– Outline description of test object (including number of poles, interlocking system, busbar system, earthing system, and the arc extinguishing process);
– Make, type, and ratings of essential parts, where applicable (for example, drive mechanisms, interrupters, shunt impedances, relays, fuse links, insulators);
– Rated characteristics of fuse links and protective devices;
– Whether the apparatus is intended for operation in the vertical and horizontal plane;
– Mock-ups (if used) details shall also be given.

A.3 Drawings

Drawings to be submitted	Drawing content (as applicable)
Single-line diagram of main circuit	Type designation of principal components
General layout NOTE For an assembly it can be necessary to provide drawings of the complete assembly and of each switching device.	Overall dimensions Supporting structure and mounting points Enclosure(s) Pressure-relief devices Conducting parts of main circuit Earthing conductors and earthing connections Electrical clearances: – to earth, between open contacts; – between poles. Location and dimensions of barriers between poles Location of earthed metallic screens, shutters or partitions in relation to live parts Liquid insulation level Location and type designation of insulators Location and type designation of instrument transformers
Detailed drawings of insulators	Material Dimensions (including profile and creepage distances)
Arrangement drawings of cable boxes	Electrical clearances Principal dimensions Terminals Level or quantity and specifications of insulant in filled boxes Cable termination details

Drawings to be submitted	Drawing content (as applicable)
Detailed drawings of parts of the main circuit and associated components	Dimensions and material of principal parts Cross-sectional view through the axis of main and arcing contacts Travel of moving contacts Electrical clearance between open contacts Distance between point of contact separation and end of travel Assembly of fixed and moving contacts Details of terminals (dimensions, materials) Identity of springs Material and creepage distances of insulating parts
Detailed drawings of mechanisms (including coupling and drive mechanisms)	Arrangement and identity of main components of the kinematic chains to: – main contacts; – auxiliary switches; – pilot switches; – position indication. Latching device Assembly of drive mechanism Interlocking devices Identity of springs Control and auxiliary devices
Electrical diagram of auxiliary and control circuits (if applicable)	Type designation of all components

Annex B
(informative)

Determination of the equivalent RMS value of a short-time current during a short-circuit of a given duration

The method illustrated in Figure B.1 could be used to determine the short-time current, if no digital equipment provides the proper computation (refer to 7.6.3).

The total time t_t of the test is divided into 10 equal parts by verticals 0 – 0,1... 1 and the RMS value of the AC component of the current is measured at these verticals.

These values are designated: Z_0, Z_1... Z_{10}

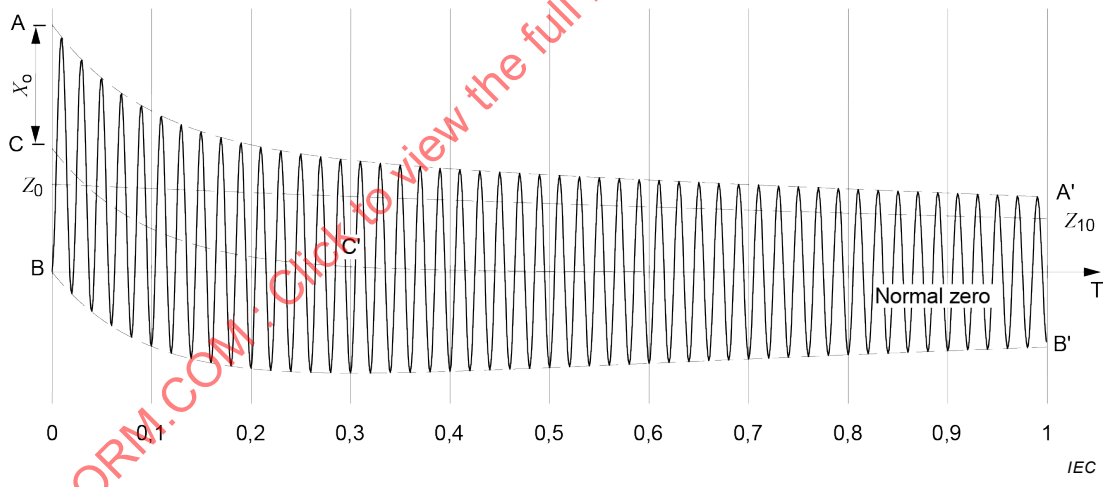
where

$Z = X/\sqrt{2}$ and X is the peak value of AC component of current.

The equivalent RMS current during the time t_t is given by:

$$I_t = \sqrt{\frac{1}{30}\left[Z_0^2 + 4\left(Z_1^2 + Z_3^2 + Z_5^2 + Z_7^2 + Z_9^2\right) + 2\left(Z_2^2 + Z_4^2 + Z_6^2 + Z_8^2\right) + Z_{10}^2\right]}$$

The DC component of current represented by CC' is not taken into account.



Key

AA'	Envelopes of current wave
BB'	
CC'	Displacement of current wave zero line from normal zero line at any instant
Z_0...Z_{10}	RMS value of AC component of current at any instant measured from normal zero
X_0	Peak value of AC component of current at instant of initiating short-circuit
BT	Duration of short-circuit, t_t

Figure B.1 – Determination of short-time current

Annex C
(normative)

Method for the weatherproofing test for outdoor switchgear and controlgear

The switchgear and controlgear to be tested shall be fully equipped and complete with all covers, screens, bushings, etc., and placed in the area to be subjected to with artificial precipitation. For switchgear and controlgear comprising several functional units a minimum of two units shall be used to test the joints between them.

The artificial precipitation shall be supplied by a sufficient number of nozzles to produce a uniform spray over the surfaces under test. The various parts of the switchgear and controlgear may be tested separately, provided that a uniform spray is simultaneously applied also to both of the following:

a) the top surfaces from nozzles located at a suitable height;

b) the floor outside the equipment for a distance of 1 m in front of the parts under test with the equipment located at the minimum height above the floor level specified by the manufacturer.

Where the width of the equipment exceeds 3 m, the spray may be applied to 3 m wide sections in turn. Pressurized enclosures need not be submitted to artificial precipitation.

Each nozzle used for this test shall deliver a square-shaped spray pattern with uniform spray distribution and shall have a capacity of 30 l/min ± 3 l/min at a pressure of 460 kPa ± 46 kPa and a spray angle of 60° to 80°. The centre lines of the nozzles shall be inclined downwards so that the top of the spray is horizontal as it is directed towards the surfaces being tested. It is convenient to arrange the nozzles on a vertical stand-pipe and to space them about 2 m apart (refer to test arrangement in Figure C.1).

The pressure in the feed pipe of the nozzles shall be 460 kPa ± 46 kPa under flow conditions. The rate at which water is applied to each surface under test shall be about 5 mm/min, and each surface so tested shall receive this rate of artificial precipitation for duration of 5 min. The spray nozzles shall be at a distance between 2,5 m and 3 m from the nearest vertical surface under test.

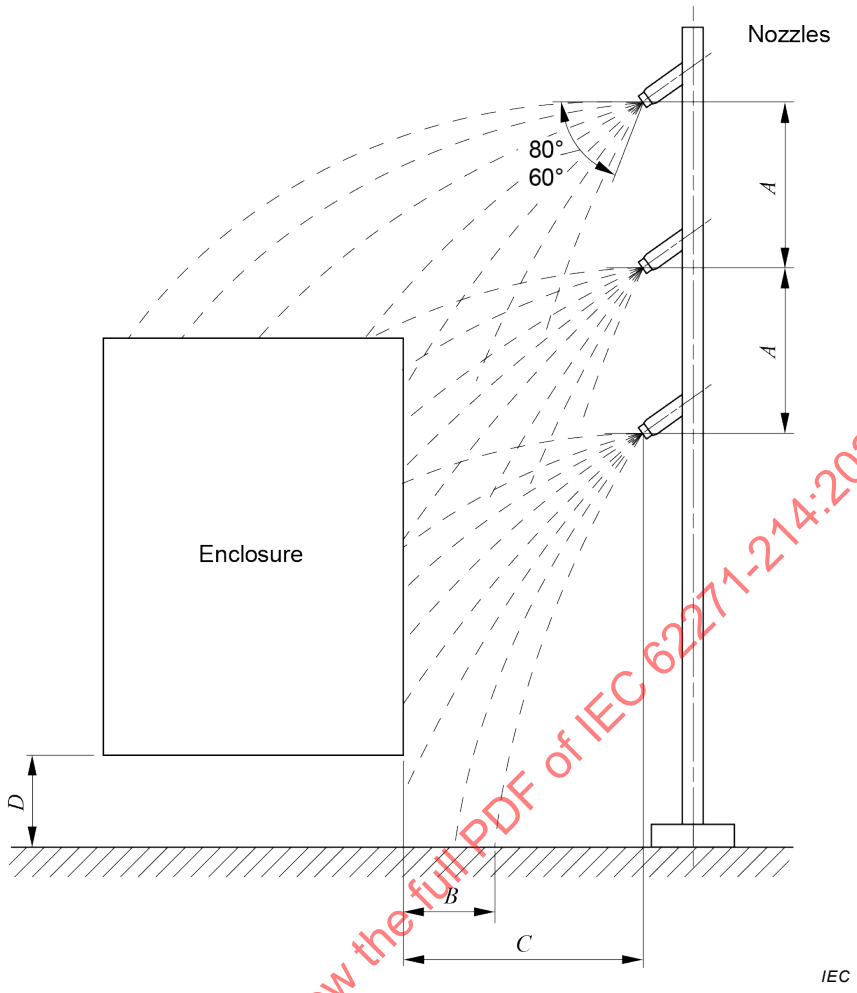
NOTE When a nozzle in accordance with Figure C.2 is used, the quantity of water is considered to be in accordance with this standard when the pressure is 460 kPa ±10 %.

After the test is completed, the equipment shall be inspected promptly to determine whether the following requirements have been met:

a) no water shall be visible on the insulation of the main and auxiliary circuits;

b) no water shall be visible on any internal electrical components and drive mechanisms of the equipment;

c) no significant accumulation of water shall be retained by the structure or other non-insulating parts (to minimize corrosion).



A	About 2 m
B	1 m
C	2,5 m to 3 m
D	Minimum height above floor

Figure C.1 – Arrangement for weatherproofing test

Dimensions in millimetres

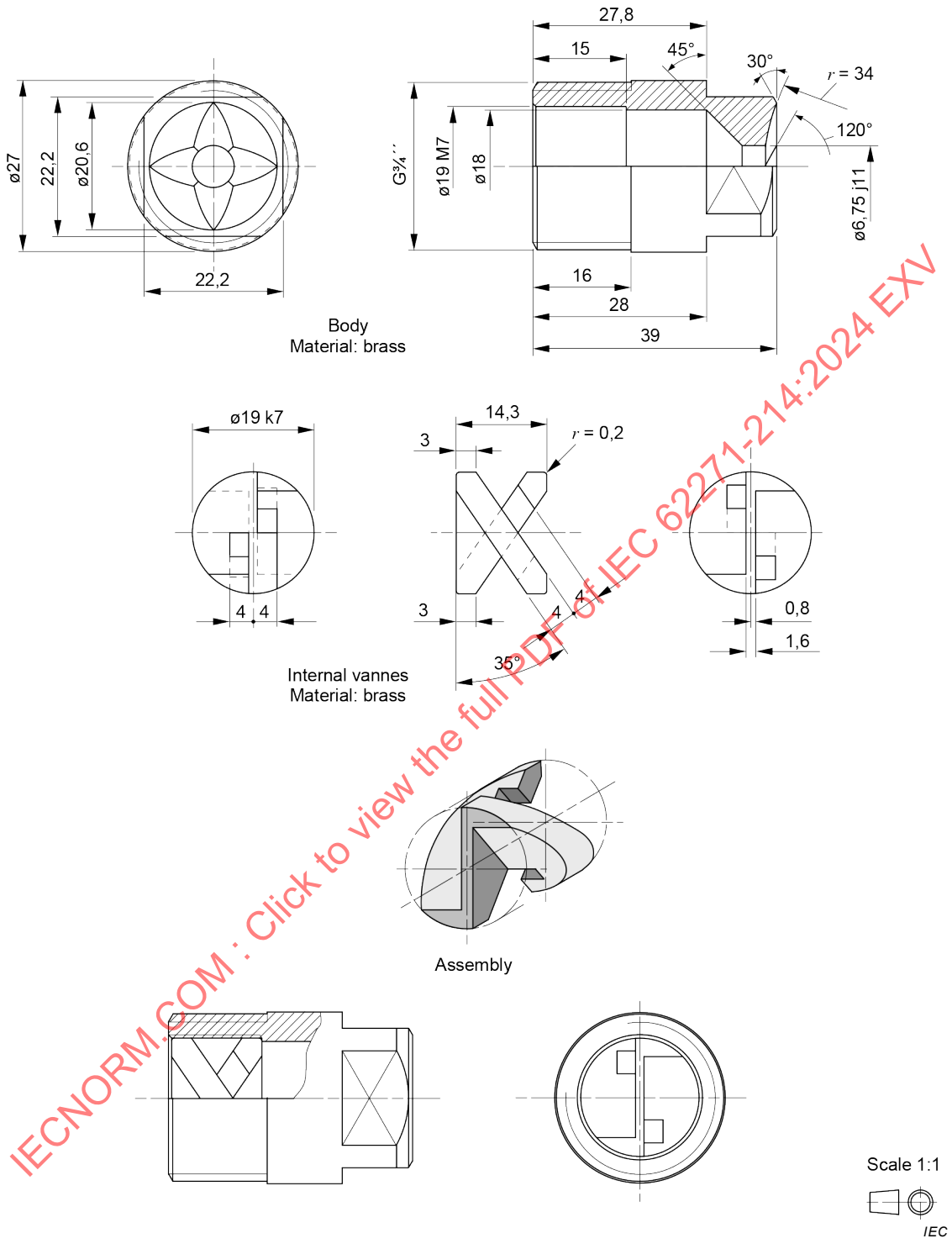


Figure C.2 – Nozzle for weatherproofing test

Annex D
(informative)

References for auxiliary and control circuit components

Table D.1 is provided as a quick reference to many of the component standards. The latest editions should be used.

Table D.1 – List of reference documents for auxiliary and control circuit components *(1 of 2)*

Device		IEC standard
Cables and wiring	Insulation of PVC wiring	IEC 60227 (all parts) [36]
	Size and area of conductors	IEC 60228 [37]
	Insulation of rubber cable	IEC 60245 (all parts)[38]
	Identification	IEC 60445 [39]
Terminals	Terminal blocks for round wire	IEC 60947-7-1 [40]
	Protective terminal blocks for round wire	IEC 60947-7-2 [41]
	Identification	IEC 60445 [39]
Relays	All-or-nothing relays	IEC 61810 (all parts) [42]
	Voltage ratings and operating range of all-or-nothing relays	IEC 61810-1 [43]
	Performance of relay contacts	IEC 61810-2 [44]
Contactors and motor starters	Electromechanical contactors for closing and opening electrical circuit	IEC 60947-4-1 [45]
	Electromechanical contactors combined with relay for short-circuit protection	IEC 60947-2 [46]
	Motor starters (AC)	IEC 60947-4-1 [45]
	AC semiconductor motor controllers	IEC 60947-4-2 [47]
	Motor protective overload relays	IEC 60947-4-1 [45]
Low-voltage switches	Low-voltage switches for motor circuits and distribution circuits	IEC 60947-3 [48]
	Manual control switches and push-buttons	IEC 60947-5-1 [49]
	Pilot switches: pressure, temperature switches etc.	IEC 60947-5-1 [49]
	Household humidity sensing controls	IEC 60730-2-13 [50]
	Household switches	IEC 60669-1 [51]
	Household thermostats	IEC 60730-2-9 [52]
	Lever (toggle) switch	IEC 61020-1 [53]
	Graphical symbols for manual switches	IEC 60417 [26]
	Colours of lights for manual switches	IEC 60073 [25]

Table D.1 *(2 of 2)*

Device		IEC standard
Low-voltage circuit-breakers and low-voltage circuit-breakers with residual current protection	Requirements	IEC 60947-2 [46]
Low-voltage fuses	General requirements	IEC 60269-1 [54]
	Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K	IEC 60269-2 [55]
Low-voltage disconnectors	Requirements	IEC 60947-3 [48]
Motors	Requirements	IEC 60034-1 [56]
Meters	Analogue meters	IEC 60051-1 [57]
	Ammeters and voltmeters	IEC 60051-2 [58]
	Frequency meters	IEC 60051-4 [59]
	Phase-angle and power-factor meters	IEC 60051-5 [60]
Lamp used as an indicator	Requirements	IEC 60947-5-1 [49]
	Graphical symbols	IEC 60417 [26]
	Colour lights	IEC 60073 [25]
Plugs, socket-outlets, and couplers	Requirements for plugs, sockets-outlet, industrial cable couplers, appliance couplers	IEC 60309-1 [61]
	Dimensional and interchangeability	IEC 60309-2 [62]
	Household plugs, socket-outlets and couplers	IEC TR 60083 [63]
	Other couplers and plugs	IEC 60130 (all parts) [64]
Printed circuit-boards	Requirements	IEC 62326-1 [65]
Resistors	Potentiometers	IEC 60393-1 [66]
	Resistors 1 W to 1 000 W	IEC 60115-4 (all parts) [67]
Illumination	Illumination fluorescents	IEC 60081 [68]
	Tungsten filament lamps	IEC 60064 [69]
NOTE For electronic components used in auxiliary and control equipment additional information can be found in IEC TR 62063 [70].		

Annex E
(normative)

Tolerances on test quantities during tests

During type tests, the following types of tolerances may normally be distinguished:

– tolerances on test quantities which directly determine the stress of the test object;
– tolerances concerning features or the behaviour of the test object before and after the test;
– tolerances on test conditions;
– tolerances concerning parameters of measurement devices to be applied.

A tolerance is defined as the range of the test value specified in the standard within which the measured test value shall lie for a test to be valid. In certain cases the test may remain valid even if the measured value falls outside the range: this is the case when it results in a more severe test condition.

Any deviation between the measured test value and the true test value caused by the uncertainty of the measurement are not taken into account in this respect.

The basic rules for application of tolerances on test quantities during type tests are as follows:

a) testing stations shall aim wherever possible for the test value specified;
b) the tolerances on test quantities specified shall be observed by the testing station. Higher stresses exceeding those tolerance are permitted only with the consent of the manufacturer;
c) where, for any test quantity, no tolerance is given within this standard, or the standard to be applied, the type test shall be not less severe than specified. The upper stress limits are subject to the consent of the manufacturer.

Table E.1 – Tolerances on test quantities for type test

Subclause	Description of the test	Test quantity	Specified test value	Test tolerances / limits of test values	Reference to
7.2 up to 7.2.12	Dielectric tests				
7.2.7.2, 7.2.8.2, 7.2.12, 7.10.5	Power-frequency voltage tests	Test voltage (RMS value)	Rated short-duration power frequency withstand voltage	±1 %	IEC 60060-1:2010
		Frequency	–	45 Hz to 65 Hz	
		Wave shape	Peak value / RMS value = √2	±5 %	
7.2.7.3 and 7.2.8.4	Lightning impulse voltage tests	Peak value	Rated lightning impulse withstand voltage	±3 %	IEC 60060-1:2010
		Front time	1,2 μs	±30 %	
		Time to half-value	50 μs	±20 %	
7.2.8.3	Switching impulse voltage tests	Peak value	Rated switching impulse withstand voltage	±3 %	IEC 60060-1:2010
		Front time	250 μs	±20 %	
		Time to half-value	2 500 μs	±60 %	
7.3 and 7.9.1.1	Radio interference voltage tests	Test voltage		±1 %	
		Tune frequency of measurement circuit		Within +10 % of 0,5 MHz or between 0,5 MHz to 2 MHz	
7.4.4	Measurement of the resistance of circuits	DC test current, I_{DC}	–	50 A < I_{DC} ≤ rated continuous current , or −20 %, +0 % of I_r ≤ 50 A	
7.5	Continuous current tests	Ambient air velocity	–	≤ 0,5 m/s	
		Test current frequency	Rated frequency	−5 %, +2 %	
		Test current	Rated continuous current	−0 %, +2 % These limits shall be kept only for the last two hours of testing period	
		Ambient air temperature T_a	--	10 °C < T_a ≤ 40 °C	
7.6	Short-time withstand current and peak withstand current tests	Test frequency	Rated frequency	±10 % at the beginning of the test, −20 %, +10 % at the end	
		Peak current (in one of the outer phases)	Rated peak withstand current	−0 %, +5 %	

Subclause	Description of the test	Test quantity	Specified test value	Test tolerances / limits of test values	Reference to
		Average of AC component of three-phase test current	Rated short-time withstand current	See tolerances for I^2t in 7.6.3	7.6.3
		Ratio of AC component of test current in any phase versus average of the three phases	1	±10 %	
		Short-circuit current duration	Rated short-circuit duration	Maximum 5 s	7.6.3
		Value of I^2t	Value I^2t Derived from rated values short-time withstand current and duration.	−0 %, +10 %	
7.9.2.3	Oscillatory wave immunity test	Damped oscillatory wave tests	Test frequency 100 kHz, 1 MHz	±30 %	IEC 61000-4-18
7.10.3.3	Auxiliary contact rated short-time withstand current	Test current amplitude		−0 %, +5 %	
		Test current duration		−0 %, +10 %	
7.10.3.4	Auxiliary contact breaking capability	Test voltage amplitude		−0 %,+10 %	
		Test current amplitude		−0 %, +5 %	
		Circuit time constant		−0 %, +20 %	
7.10.4.2	Cold tests	Minimum and maximum ambient air temperature during tests	–	±3 K	IEC 60068-2-1: 2007
7.10.4.3	Dry heat test	Minimum and maximum ambient air temperature during tests	–	±3 K	IEC 60068-2-2: 2007
7.10.4.4	Cyclic humidity test	Minimum temperature of cycle		±3 K	IEC 60068-2-30: 2005
		Maximum temperature of cycle		± 2 K	
7.10.4.5	Vibration response and seismic tests				IEC 60255-21-1: 1988
7.11.1.3	Radiation instrument	Accuracy measurement of radiation		±25 %	
	Energy response	Accuracy measurement of energy		±15 %	

Annex F
(informative)

Information and technical requirements to be given with enquiries, tenders and orders

F.1 General

This annex provides a list of useful technical information items in a tabular form to be considered for possible exchange between user and supplier during contracting stage.

When in the table "supplier information" is mentioned, this means that only the supplier needs to deliver this information.

Attention should be paid to the fact that such table should be complemented with information and characteristics relevant for the type of switchgear and controlgear considered; see product standards.

F.2 Normal and special service conditions (refer to Clause 4)

		User requirements	Supplier proposals
Service condition	Indoor or outdoor		
Ambient air temperature: Minimum Maximum	 °C °C		
Solar radiation	W/m^2		
Altitude	m		
Pollution	Class		
Excessive dust or salt			
Ice coating	mm		
Wind	m/s		
Humidity	%		
Condensation or precipitation			
Vibration	Class		
Induced electromagnetic disturbance in auxiliary and control circuits	kV		

F.3 Ratings (refer to Clause 5)

		User requirements	Supplier proposals
Rated voltage for equipment (U_r)	kV		
Rated insulation levels phase to earth and between phases			
Rated short-duration power-frequency withstand voltage (U_d)	kV		
Rated switching impulse withstand voltage (U_s)	kV		
– phase to earth	kV		
– between phases	kV		
Rated lightning impulse withstand voltage (U_p)	kV		
Rated frequency (f_r)	Hz		
Rated continuous current (I_r)	A	According single line	
Rated short-time withstand current (I_k)	kA		
Rated peak withstand current (I_p)	kA		
Rated duration of short-circuit (t_k)	s		
Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)	V		
Rated supply frequency of closing and opening devices and of auxiliary circuits	Hz	DC or 50 or 60	

F.4 Design and construction (refer to Clause 6)

To be complemented with information provided by relevant product standards.

		User requirements	Supplier proposals
Number of phases	Three- or single-phase encapsulation		
Mass of the heaviest transport unit			
Mounting provisions			
Type of gas-pressure or liquid-pressure system			
Overall dimensions of the installation			
Description by name and category of the various compartments			
Rated filling level and minimum functional level			
Low- and high-pressure interlocking and monitoring devices			
Interlocking devices			
Degrees of protection			
Arrangement of the external connections			
Accessible sides			
Volume of liquid or mass of gas or liquid for the different compartments			
Facilities for transport and mounting			

		User requirements	Supplier proposals
Instructions for operation and maintenance			
Specification of gas or liquid condition			

F.5 System information

		User information
Nominal voltage of system	kV	
Highest voltage of system	kV	
Number of phases		
Type of system neutral earthing		Effectively or non-effectively

F.6 Documentation for enquiries and tenders

	User requirements	Supplier proposals
Scope of supply (training, technical and layout studies and requirements for co-operation with other parties)		
Single-line diagram		
General arrangement drawings of substation layout		
Provisions for transport and mounting to be given by the user		
Foundation loading	Supplier information	
Gas schematic diagrams	Supplier information	
List of type test reports	Supplier information	
List of recommended spare parts	Supplier information	

Annex G
(informative)

List of symbols

Description	Symbol	Subclause
Absolute leakage rate	F	3.6.6.4
Absolute leakage rate	F_{liq}	3.6.7.1
Alarm pressure (or density) for insulation and/or switching	p_{ae} (ρ_{ae})	3.6.5.3
Alarm pressure for operation (or density)	p_{am} (ρ_{am})	3.6.5.4
Filling pressure	p_r	7.8.2
Filling pressure (or density) for insulation and/or switching	p_{re} (ρ_{re})	3.6.5.1
Filling pressure (or density) for operation	p_{rm} (ρ_{rm})	3.6.5.2
Main circuit resistance measured before continuous current test	R_u	8.4
Measured pressure	p_m	7.8.2
Minimum functional pressure (or density) for insulation and/or switching	p_{me} (ρ_{me})	3.6.5.5
Minimum functional pressure for operation (or density)	p_{mm} (ρ_{mm})	3.6.5.6
Number of replenishments per day	N	3.6.6.8
Number of replenishments per day	N_{liq}	3.6.7.3
Partial voltage with respect to earth	U_f	7.2.6.3 b)
Permissible leakage rate	F_p	3.6.6.5
Permissible leakage rate	$F_{p(liq)}$	3.6.7.2
Pressure drop	Δp	3.6.6.9
Pressure drop	Δp_{liq}	3.6.7.4
Protection against ingress of water coding	IP	6.14.3
Protection of equipment against mechanical impact under normal service conditions coding	IK	6.14.4
Radio interference voltage test	RIV	7.3
Rated continuous current	I_r	5.5
Rated duration of short-circuit	t_k	5.8
Rated frequency	f_r	5.4
Rated lightning impulse withstand voltage	U_p	5.3
Rated peak withstand current	I_p	5.7
Rated short-duration power-frequency withstand voltage	U_d	5.3
Rated short-time withstand current	I_k	5.6
Rated supply voltage	U_a	5.9.2
Rated supply voltage of closing and opening devices and of auxiliary and control circuits	U_a	5.9
Rated switching impulse withstand voltage	U_s	5.3
Rated voltage	U_r	5.2
Relative leakage rate	F_{rel}	3.6.6.6
Time between replenishments	t_r	3.6.6.7
Total test voltage	U_t	7.2.6.3 b)

Annex H
(informative)

Electromagnetic compatibility on site

EMC site measurements are not type tests but may be performed in special situations:

– where it is deemed necessary to verify that actual stresses are covered by the EMC severity class of the auxiliary and control circuits;

– in order to evaluate the electromagnetic environment;

– in order to apply proper mitigation methods, if necessary;

– to record the electromagnetically induced voltages in auxiliary and control circuits, due to switching operations both in the main circuit and in the auxiliary and control circuits. It is not considered necessary to test all auxiliary and control circuits in a substation under consideration. A typical configuration should be chosen.

Measurement of the induced voltages should be made at representative ports in the interface between the auxiliary and control circuits and the surrounding network, for example, at the input terminals of control cubicles, without disconnection of the system. Instrumentation for recording induced voltages should be connected as outlined in IEC TR 60816 [71].

Switching operations should be carried out at normal operating voltage, both in the main circuit and in the auxiliary and control circuits. Induced voltages will vary statistically and thus a representative number of both making and breaking operations should be chosen, with random operating instants.

The switching operations in the main circuit are to be made under no-load conditions. The tests will thus include the switching of parts of the substation but no switching of load currents and no fault currents.

The making operations in the main circuit should be performed with trapped charge on the load side corresponding to normal operating voltage. This condition may be difficult to obtain at testing, and, as an alternative, the test procedure may be as follows:

– discharge the load side before the making operation, to assure that the trapped charge is zero;

– multiply recorded voltage values at the making operation by 2, in order to simulate the case with trapped charge on the load side.

The switching device in the primary system shall preferably be operated at rated pressure and auxiliary voltage.

NOTE 1 The most severe cases, with regard to induced voltages, will normally occur when only a small part of a substation is switched.

NOTE 2 The most severe electromagnetic disturbances are expected to occur at disconnector switching, especially for GIS installations.

The recorded or calculated peak value of induced common-mode voltage, due to switching in the main circuit, should not exceed 1,6 kV for interfaces of the auxiliary and control circuits.

Annex I
(informative)

List of notes concerning certain countries

With reference to Annex SC of *IEC/ISO Directives Supplement – Procedures specific to IEC*, (2016), an IEC National Committee may provide a statement to be included in an International Standard, informing the user of the standard of particular conditions existing in its country.

Clause	Text
6.14.1	NOTE In addition to IEC 60529 enclosures are to be designed to prevent unauthorized access by provided provisions for locking or requiring a special tool to open doors. Doors hinges and access panels are not externally removable (US).
6.14.2	NOTE The minimum default code is IP2XB (US)
7.2.12	NOTE The required test voltage for disconnectors and switch disconnectors of all rated voltages is 100 % of the tabulated voltage in columns (3) of Tables 1 or 2 and 3 or 4 (Canada).

Annex J
(informative)

Extension of validity of type tests

J.1 General

An individual type test need not be repeated in some situations e.g.:

– for a change of construction detail, if the manufacturer can establish that this change does not influence the result of that individual type test;

– for a change in the installation instructions, provided that the test conditions are not invalidated by the new instructions (e.g. see J.2);

– for covering other values of ratings for the same switchgear and controlgear, if these new ratings are covered by the tests already performed (e.g. see J.3 or when lower performances are requested).

Particular examples where extension of a type test may be used to validate design changes or other similar equipment, without repeating type tests, are given in the following subclauses. It should be noted that supporting evidence should be provided to validate such extensions of type tests.

More details may be given in the product standards and/or technical reports, e.g. IEC TR 62271-307 [72].

J.2 Dielectric tests

For non-enclosed conductors, the dielectric tests performed cover other dispositions having equal or higher clearances to surroundings (e.g. height above ground) and between conductors, if the insulating materials and shapes of conductors and insulators are the same.

J.3 Short-time withstand current tests

Short-time withstand current and peak withstand current tests performed at 50 Hz or 60 Hz, using a peak factor of 2,6, cover both frequencies for networks having a DC time constant of 45 ms or smaller.

Short-time withstand current and peak withstand current tests performed at 50 Hz or 60 Hz using a peak factor of 2,7, cover both frequencies for any DC time constants.

J.4 Continuous current test

A test performed on a single pole, or on a single unit, covers larger arrangements (i.e. three pole or multiple units) provided that the influence with other poles or other units is negligible, as it is generally the case for non-enclosed switchgear and controlgear; this provision is applicable, for instance, to some outdoor transmission devices.

As stated in 7.5.3.1:

– for switchgear and controlgear rated for both frequencies at 50 Hz and 60 Hz and having no ferrous components adjacent to the current-carrying parts, test can be performed at 50 Hz and cover both frequencies provided that the temperature-rise values recorded during the tests at 50 Hz do not exceed 95 % of the maximum permissible values;

– tests performed at 60 Hz cover both frequencies.

J.5 Electromagnetic immunity test on auxiliary and control circuits

Subassemblies may be positioned in different places within the auxiliary and control circuits, without invalidating the type test of the complete system, provided that the overall wiring length and the number of individual wires connecting the subassembly to the auxiliary and control circuits is not greater than in the tested system.

Interchangeable subassemblies may be replaced by similar subassemblies, without invalidating the original type test, provided that:

– rules for design and installation given in IEC 61000-6-5 are followed;
– type tests have been performed on the most complete subassembly applicable to the type of switchgear and controlgear;
– manufacturer's design rules are the same as for the type-tested subassembly.

J.6 Environmental tests on auxiliary and control circuits

Environmental tests on auxiliary and control circuits need not be repeated if performance requirements are validated during environmental tests on a whole switchgear and controlgear.

Parts, or pieces of equipment, of auxiliary and control circuits validated in a given arrangement are validated also when used in a different arrangement of auxiliary and control circuits belonging to the same range of switchgear and controlgear equipment.

Tests performed with a given supply voltage for auxiliary and control circuit cover similar auxiliary and control circuits designed for lower supply voltages.

Annex K
(informative)

Exposure to pollution

K.1 General

The quality of ambient air with respect to pollution by dust, smoke, corrosive and/or flammable gases, vapours, or salt is a consideration under normal and special service conditions (refer to Clause 4 of this document). This annex defines levels of pollution as well as recommendations for the minimum specific creepage distance across external insulation.

K.2 Pollution levels

For purposes of standardization, the levels of pollution, very light, light and medium, are qualitatively defined. The qualitative examples given in Table K.1 are approximate descriptions of some typical corresponding environments. Other more extreme environmental conditions may merit further consideration, e.g., snow and ice in heavy pollution, heavy rain, and arid areas. For these special conditions, reference is given to IEC TS 60815-1:2008, IEC TS 60815-2:2008 and IEC TS 60815-3:2008.

K.3 Minimum requirements for switchgear

The minimum creepage distance expressed as a specific creepage in mm/kV are for the normal service conditions of atmospheric contamination and altitudes up to 1 000 m. This minimum creepage provides generally satisfactory service operation under these conditions.

For each level of pollution described in Table K.1, the corresponding minimum recommended nominal unified specific creepage distance (USCD) in mm/kV across the insulator is given in Table K.2.

NOTE The information in Table K.1 is adapted from IEC TS 60815-1:2008; the values in Table K.2 are taken from IEC TS 60815-2:2008.

Table K.1 – Environmental examples by site pollution severity (SPS) class

SPS Class	Example of typical environments
Very light	Example 1: > 50 km[a] from any sea, desert, or open dry land > 10 km from man-made pollution sources [b] Within a shorter distance than mentioned above of pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing
Light	Example 2: 10 km to 50 km[a] from the sea, a desert, or open dry land 5 km to 10 km from man-made pollution sources [b] Within a shorter distance than example 1 from pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing
Medium	Example 3: 3 km to 10 km[c] from the sea, a desert, or open dry land 1 km to 5 km from man-made pollution sources [b] Within a shorter distance than mentioned above of pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing Example 4: Further away from pollution sources than mentioned in example 3, but: • dense fog (or drizzle) often occurs after a long (several weeks or months) dry pollution accumulation season • and/or heavy, high conductivity rain occurs • and/or there is a high non-soluble deposit level (refer to IEC TS 60815-1:2008)
Heavy and Very heavy	Refer to IEC TS 60815-1:2008.

[a] During a storm, the ESDD level at such a distance from the sea may reach a much higher level.

[b] The presence of a major city will have an influence over a longer distance, i.e. the distance specified for sea, desert and dry land.

[c] Depending on the topography of the coastal area and the wind intensity.

Table K.2 – Minimum nominal specific creepage distance by pollution level

SPS class	Minimum recommended nominal unified specific creepage distance (USCD) [a] mm/kV
Very light	22
Light	27,8
Medium	34,7
Heavy and Very heavy	Refer to IEC TS 60815-1:2008, IEC TS 60815-2:2008, and IEC TS 60815-3:2008

[a] The unified specific creepage distance (USCD) is the creepage distance of an insulator divided by the RMS value of the highest operating voltage across the insulator.

[SOURCE: IEC TS 60815-2:2008, 3.2]

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[5] IEC Guide 108, *Guidelines for ensuring the coherency of IEC publications – Application of horizontal standards*

[6] IEC 60721-2-4, *Classification of environmental conditions – Part 2-4: Environmental conditions appearing in nature – Solar radiation and temperature*

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[8] IEC 60721-2-2, *Classification of environmental conditions – Part 2-2: Environmental conditions appearing in nature – Precipitation and wind*

[9] IEC 60721-3-3, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weatherprotected locations*

[10] IEC 60721-3-4, *Classification of environmental conditions – Part 3-4: Classification of groups of environmental parameters and their severities – Stationary use at non-weatherprotected locations*

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

[12] IEC TS 62271-304, *High voltage switchgear and controlgear – Part 304: Design classes for indoor enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV to be used in severe climatic conditions*

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[30] IEC 60695-7 (all parts), *Fire hazard testing – Part 7:Toxicity of fire effluent*

[31] IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

[32] CISPR 16-1 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

[33] IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

[34] IEC TR 60909-1, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculations of short-circuit currents according to IEC 60909-0*

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[40] IEC 60947-7-1, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

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[61] IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

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[1] IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Part 601: Generation, transmission and distribution of electricity – General*
IEC 60050-601:1985/AMD1:1998
IEC 60050-601:1985/AMD2:2020

[2] IEC 62271-200:2021, *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*

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IEC 62271-214

Edition 2.0 2024-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage switchgear and controlgear – Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

Appareillage à haute tension – Partie 214 : Classification arc interne des appareillages sous enveloppe métallique à courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV montées sur poteau

IEC 62271-214:2024-04(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
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9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62271-214 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2019. This edition constitutes a technical revision.

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

a) indicators positioning update;
b) neutral earthing connection of the test circuit for three-phase tests;
c) general review for consistency with IEC 62271-200, Ed.3.0:2021.

The text of this International Standard is based on the following documents:

Draft	Report on voting
17C/924/FDIS	17C/931/RVD

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

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/publications.

This standard shall be read in conjunction with IEC 62271-1, second edition, published in 2017, to which it refers, and which is applicable unless otherwise specified in this standard. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1. Amendments to these clauses and subclauses are given under the same references whilst additional subclauses are numbered from 101. Any clause with the term "Not applicable" relates to the clause not being relevant to IEC 62271-214, and does not infer the clause is or is not relevant for its applicable switchgear standard.

A list of all parts of 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 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.

INTRODUCTION

IEC 62271-214 has been developed due to the requirement to remove IAC Type C designated pole-mounted switchgear from IEC 62271-200. IEC 62271-214 is to be considered independent of IEC 62271-200, however it is still related to other product standards of the IEC 62271 series.

Only open terminal pole-mounted switchgear and controlgear has been considered within this document.

This equipment relates to operation in three-phase, two-phase and single-phase systems.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 214: Internal arc classification for AC metal-enclosed pole-mounted switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

1 Scope

This part of IEC 62271 specifies requirements for internal arc classification of AC metal-enclosed pole-mounted switchgear and controlgear with rated voltages above 1 kV and up to and including 52 kV with service frequencies up to and including 60 Hz.

This document is applicable to three-phase, two-phase and single-phase open terminal equipment for which an internal arc classification is assigned. Enclosures may include fixed and removable components and may be filled with fluid (liquid or gas) to provide insulation.

NOTE 1 The IAC classification takes into account the installation disposition of the high-voltage switchgear and controlgear and worker's operating area.

NOTE 2 For the use of this document, high-voltage (IEC 60050-601:1985, 601-01-27) is the rated voltage above 1 000 V. However, medium voltage (IEC 60050-601:1985, 601-01-28) is commonly used for distribution systems with voltages above 1 kV and generally applied up to and including 52 kV; refer to [1][1].

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

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 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014
IEC 60050-151:2001/AMD3:2019
IEC 60050-151:2001/AMD4:2020
IEC 60050-151:2001/AMD5:2021

IEC 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*
IEC 62271-1:2017/AMD1:2021

[1] Numbers in square brackets refer to the Bibliography.

IEC 62271-200:2021, *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*

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, as well as the following apply.

NOTE 1 The classification system for definitions of IEC 62271-1:2017 is not 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 terminology databases for use in standardization at the following addresses:

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

NOTE 2 Additional definitions are classified so as to be aligned with the classification system used in IEC 60050-441.

3.1 General terms and definitions

3.1.101
metal-enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external metal enclosure intended to be earthed, and completely assembled except for external connections

[SOURCE: IEC 60050-441:1984, 441-12-04, modified – "complete" has been replaced by "completely assembled"; NOTE has been deleted.]

3.1.102
enclosure
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, modified – <of an assembly> has been deleted.]

3.1.103
high-voltage compartment
compartment of switchgear and controlgear, containing high-voltage conducting parts, enclosed except for openings necessary for interconnection, control or ventilation, where one segment of the compartment can be part of the outer earthed metallic enclosure

3.1.104
component
essential part of the high-voltage or earthing circuits of pole-mounted switchgear and controlgear which serves a specific function (e.g. circuit-breaker, disconnector, switch, fuse, instrument transformer, bushing, busbar)

3.1.105
main circuit
all the high-voltage conductive parts of pole-mounted switchgear and controlgear included in a circuit which is intended to carry the rated continuous current

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – "high voltage" has been added, "assembly" has been substituted by "pole-mounted switchgear and controlgear" and "transmit electrical energy" has been substituted by "carry the rated continuous current".]

3.1.106
earthing circuit
conductors, connections, and the conducting parts of earthing devices intended to connect the high-voltage conductive parts to the earthing system of the installation

Note 1 to entry: Parts of metallic enclosures connected to the earthing system can be part of the earthing circuit.

3.1.107
normal operating condition
in service condition with all covers properly closed and secured

Note 1 to entry: The term "in service" implies "under live conditions".

[SOURCE: IEC 62271-200:2021[2], 3.1.106, modified – "<of an assembly>" and "doors and" have been removed and Note 1 to entry has been added.]

3.1.108
pressure relief device
device incorporated as part of an enclosure or compartment intended to operate to prevent excessive pressure in the enclosure or compartment

3.1.109
fluid-filled compartment
high-voltage compartment of pole-mounted switchgear and controlgear filled with a fluid, either gas, other than ambient air, or liquid, for insulation purposes

3.1.110
pole
vertical single member support in wood, concrete, steel or other material, with one end buried in the ground, either directly or by means of a foundation

Note 1 to entry: The term pole as defined here is not to be mixed up with the use of the same term as synonymous for phase as used in other standards.

[SOURCE: IEC 60050-466:1990, 466-07-01[8], modified – Note 1 to entry has been added.]

3.1.111
pole-mounted switchgear and controlgear
metal-enclosed switchgear and controlgear, typically connected to overhead lines, installed on one or more poles or equivalent structures at a defined height, with restricted accessibility by installation out of reach

3.1.112
internal arc classification
IAC
metal-enclosed switchgear and controlgear for which prescribed criteria, for protection of authorized persons and the general public beneath the apparatus, 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 described by the characteristics given from 3.1.114 to 3.1.116.

[SOURCE: IEC 62271-200:2021, 3.6.117, modified – "authorized" and "and general public beneath the apparatus" have been added, "assembly" has been changed by "metal-enclosed switchgear and controlgear".]

3.1.113
arc fault current
three-phase and where applicable the single-phase-to-earth RMS value of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

[SOURCE: IEC 62271-200:2021, 3.7.101]

3.1.114
arc fault duration
duration of the internal arc fault current for which the switchgear and controlgear is designed to protect persons in the event of an internal arc

[SOURCE: IEC 62271-200:2021, 3.7.102]

3.1.115
approach distance
distance between the test object and indicators arranged in an IAC test

3.1.116
arc mitigation device
device dedicated to reacting to internal arc fault conditions to decrease the arc energy

[SOURCE: CIGRE TECHNICAL BROCHURE 686:2017][5]

3.8 Index of definitions

A – C

E – F

H – I

M – N

P

4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable.

5 Ratings

Subclauses of Clause 5 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 not mentioned below are not applicable for this document.

5.1 General

Subclause 5.1 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable and replaced by following text:

The relevant ratings for the internal arc classification are the following:

a) rated voltage (U_r);

b) rated frequency (f_r);

c) ratings of the internal arc classification (IAC).

5.2 Rated voltage (U_r)

Subclause 5.2 of IEC 62271-1:2017 is applicable with following addition to 5.2.1.

5.2.1 General

The rated voltage is equal to the maximum system voltage for which the equipment is designed. It indicates the maximum value of the "highest system voltage" of networks for which the equipment may be used (refer to Clause 9 of IEC 60038:2009 [6]).

NOTE It is possible that components forming part of pole-mounted switchgear and controlgear have differing values of rated voltage in accordance with their relevant standards.

5.3 Rated insulation level (U_d, U_p, U_s)

Not applicable.

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is applicable.

5.101 Ratings of the internal arc classification (IAC)

5.101.1 General

An IAC classified pole-mounted switchgear and controlgear shall have the following ratings: rated approach distance, arc fault currents and arc fault durations.

5.101.2 Rated approach distance (D_{AP})

The rated approach distance shall be stated by the manufacturer (refer to Figure 2).

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

The value of rated arc fault currents should be selected from the R 10 series specified in IEC 60059 [7].

Two ratings of the arc fault currents are recognised:

a) three-phase and phase-to-phase arc fault current (I_A), when applicable;

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

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

NOTE 1 The rationale for this 87 % is the arc fault test with 2-phase ignition; refer to 7.101.7.2.

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

In the case where all high-voltage compartments are only designed for single-phase-to-earth arc faults, instead of I_A rating, the I_{Ae} rating shall be assigned (refer to 7.101.7.2).

NOTE 2 Information about the relationship between type of neutral earthing and the single-phase-to-earth arc fault current is provided in 9.101.6.

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

Recommended values for the arc fault duration (t_A, t_{Ae}) are 0,1 s, 0,5 s and 1 s.

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

Subclauses of Clause 6 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 not mentioned below are not applicable for this document.

6.11 Nameplate

6.11.2 Application

Subclause 6.11.2 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is applicable, except for Table 9, with the following additions:

Pole-mounted switchgear and controlgear, with a rated internal arc classification shall include in the nameplate the additional IAC information in accordance with Table 1.

Table 1 – Nameplate information

	Abbreviation	Unit	**	Condition: Marking only required if
(1)	(2)	(3)	(4)	(5)
Internal arc classification	IAC		X	
Rated approach distance	D_{AP}	m	X	
Arc fault current and duration	I_A, t_A	kA, s	Y	Three-phase test or phase-to-phase test are applicable
Single-phase-to-earth arc fault current and duration	I_{Ae}, t_{Ae}	kA, s	Y	A single-phase test is applicable or I_{Ae} differs from 87 % of I_A
Fitted with arc mitigation device			Y	Arc mitigation device fitted and not disabled during testing
(**) X : the marking of these values is mandatory Y : conditions for marking of these values are given in column (5)				
NOTE If there is an abbreviation in column (2) it can be used instead of the terms in column (1).				

6.101 Internal arc fault

Pole-mounted switchgear and controlgear, in principle, are designed and manufactured, to prevent the occurrence of internal arc faults.

However, the switchgear and controlgear shall be designed to give a defined level of protection of persons in the event of an internal arc, when the switchgear and controlgear is in normal operating condition.

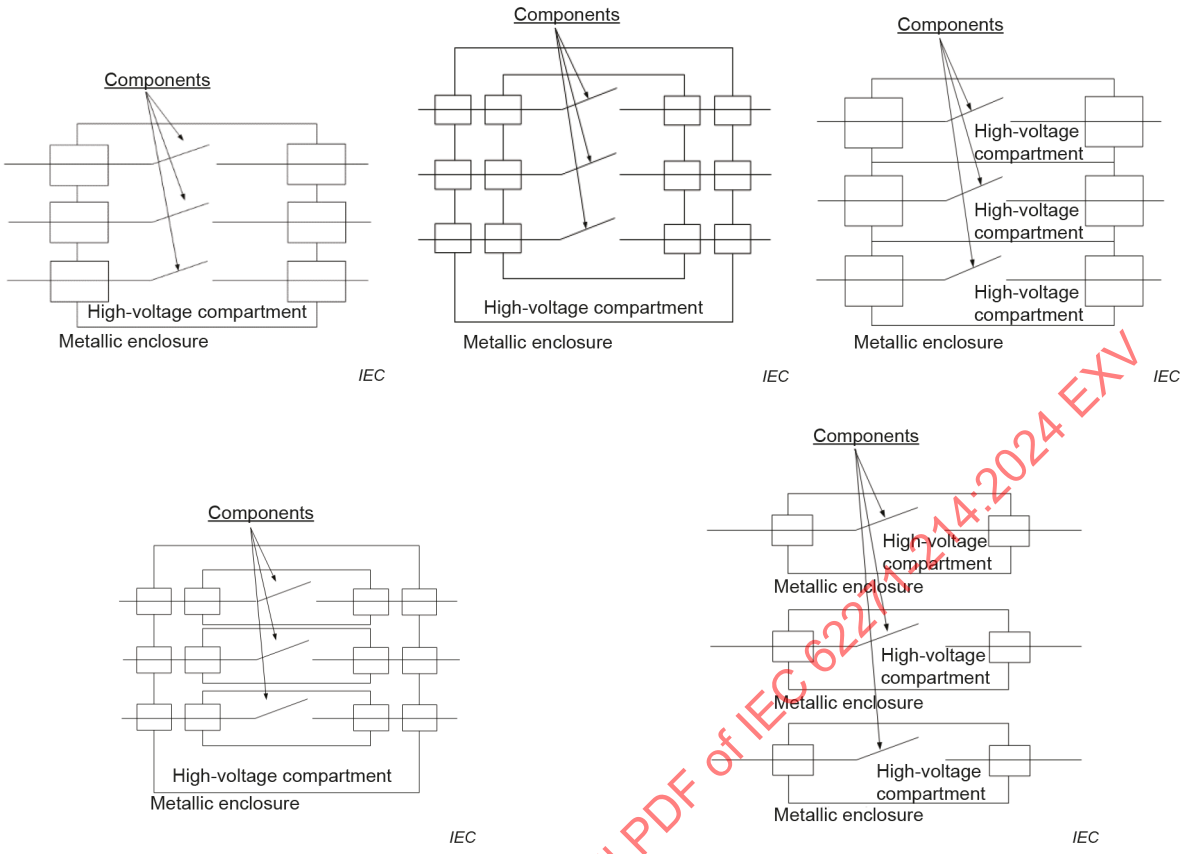
The designation shall be included in the nameplate (refer to 6.11).

Some examples for internal arc classification are given in 7.101.7.2.5.

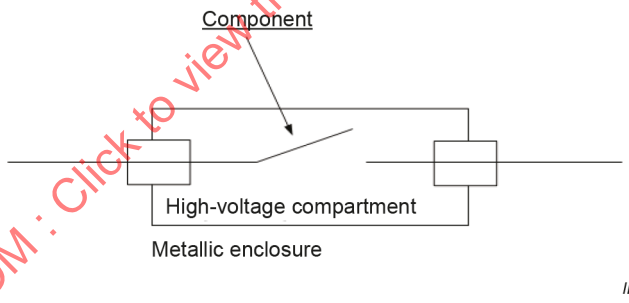
6.102 Enclosure

The enclosure is designed for withstanding the mechanical, electrical, thermal and environmental stresses likely to be encountered in normal operating condition and under conditions of internal arc fault.

Figure 1 shows examples of different arrangements of components in high voltage compartment(s) within an enclosure.



a) three-phase



b) single-phase

Figure 1 – Examples of enclosures and compartment(s) in different arrangements

7 Type tests

Subclauses of Clause 7 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 not mentioned below are not applicable for this document.

7.1 General

7.1.1 Basics

The type test is performed to verify the internal arc ratings and characteristics of pole-mounted switchgear and controlgear.

7.1.2 Information for identification of test object

Subclause 7.1.2 of IEC 62271-1:2017 does not apply for this document and is replaced by following text.

The manufacturer shall submit to the testing laboratory, drawings and other data containing sufficient information to unambiguously identify by type the essential details and parts of the switchgear and controlgear presented for test. A summary list of the drawings and data schedules shall be supplied by the manufacturer and shall be uniquely referenced and shall contain a statement to the effect that the manufacturer guarantees that the drawings or data schedules listed are the correct version and truly represent the switchgear and controlgear to be tested.

The testing laboratory shall check that drawings and data sheets adequately represent the essential details and parts of the test object, but is not responsible for the accuracy of the detailed information.

Particular drawings or data required to be submitted by the manufacturer to the test laboratory for identification of essential parts of test object are specified in Annex A.

7.1.3 Information to be included in type-test reports

The results shall be recorded in type-test reports containing sufficient data to prove compliance with the test clauses of this document for the test(s) conducted. Sufficient information shall be included so that the essential parts of the test object can be identified. In particular, the following information shall be included:

– manufacturer;
– type designation and unique identifier for the test object;
– rated characteristics of the test object;
– photographs to illustrate the condition of the test object before and after test;
– sufficient outline drawings and data schedules to represent the test object;
– the reference numbers of all drawings including revision number submitted to identify the essential parts of the test object;
– details of the testing arrangement (including diagram of test circuit);
– statements of the behaviour of the test object during test and its condition after test;
– description of the test object with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief device(s) and the method of fixing the test object to the pole(s), including the pole characteristics;
– point and method of initiation of the internal arc fault;
– drawings of test arrangement (test object, source side connection point, and mounting frame of indicators, pole dimensions) and any other relevant installation conditions; applied voltage and frequency;
  - IAC designation validated by test;
  - include use of fuse protection if used;
  - include the use of arc mitigation device if used;
– for the prospective and/or test current (refer to 7.101.6.3):
  a) RMS value of the AC component during:
     - the first three half-cycles;
     - the last three half-cycles;
  b) highest peak value (actual and/or prospective);
  c) average RMS value of the AC component over the actual duration of the test;

d) duration of arc fault current;

e) 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 7.101.8;

– other relevant remarks.

7.101 Internal arc type test

7.101.1 General

The test is applicable to pole-mounted switchgear and controlgear for which internal arc classification is assigned, covering the event of an arc fault within the enclosure(s) or within components having housings which form part of the enclosure in normal operating condition. 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, and for the effects of ejected hot gases and glowing particles on the persons situated beneath the apparatus under test.The tests are not intended to cover e.g.:

– the influences of an internal arc between compartments;

– the effect of an arc on the external connections outside the enclosure;

– 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 pole-mounted switchgear and controlgear.

7.101.2 Test conditions

The test shall be carried out with the switchgear and controlgear in normal operating condition. This means the position of high-voltage switching devices is set according to 7.101.7.1.4. All other equipment, for example measuring instruments and monitoring equipment shall be in the position as it is in normal operating condition.

Pole-mounted switchgear and controlgear which are protected by type-tested current-limiting fuses, integrated inside the switchgear and controlgear, 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 tests shall be performed at the rated voltage of the equipment. The tested switchgear and controlgear will be designated as 'fuse-protected'. The specific fuse, including manufacturer, part number, and ratings, used for protection shall be specified in the instructions manual.

Application of suitable current-limiting fuses in combination with switching devices can limit the short-circuit current and minimize the fault duration. It is well documented that the arc energy transferred during such tests is not predictable by I^2t. In the case of current-limiting fuses, the maximum arc energy may occur at current levels below the maximum interrupting rating. Further, the effects of using current-limiting devices that employ pyrotechnic means to commutate current to a current-limiting fuse shall be considered when evaluating designs utilizing such devices.

Any device (for example, protection relay) that may automatically trip the circuit before the end of the prospective duration of the test shall be made inoperative during the test. If pole-mounted switchgear and controlgear is equipped with devices intended to limit the duration of the arc itself by other means (for example, by transferring the current to a metallic short circuit), they shall be made inoperative during the test. If these devices are an integral part of the design of the high-voltage compartment or assembly which prevents them being made inoperative without modification of the construction, the relevant high-voltage compartment of the switchgear and controlgear may be tested with the device operative; but this switchgear and controlgear shall be qualified according to the actual duration of the arc. The test current shall be maintained for the rated arc fault duration of the switchgear and controlgear.

NOTE Because in general arc limiting devices are out of the scope of this document and if the switchgear and controlgear has previously been tested with the limiting device made inoperative, an additional test can be performed to demonstrate the behaviour of this arc limiting device.

7.101.3 Arrangement of the equipment

The test arrangement for pole-mounted switchgear and controlgear shall be configured as indicated in Figure 2.

Dimensions in millimetres

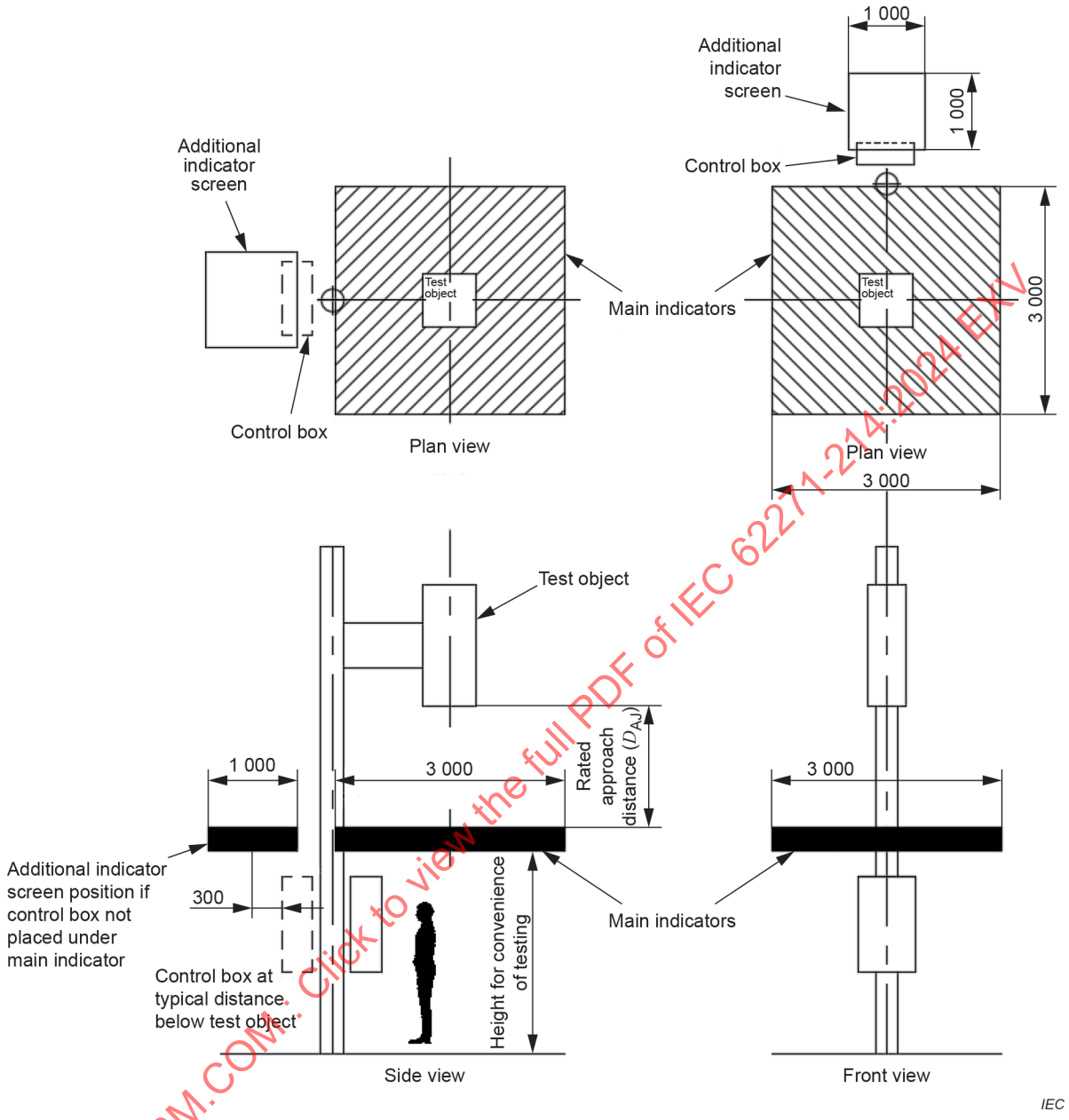


Figure 2 – Test arrangement for pole-mounted switchgear and controlgear

The equipment shall be arranged as follows:

– 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;

– the test object shall be mounted on a pole. If there is a control box and/or electrical/mechanical linkages to the base of the pole, these shall be fitted at a distance below the test object typical of a service installation. The test object shall be at a convenient height allowing for the indicators as specified in 7.101.5, and for the control box and/or electrical/mechanical linkages (if applicable);

– In the case the control box is not fully covered by the main indicators the test shall include a 1 000 mm × 1 000 mm indicator screen above control box, refer to Figure 2;

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

– tests shall be carried out on high-voltage compartments not previously subjected to arcing, or, if subjected, being in a condition which does not affect the result of the test;
– in the case of fluid-filled compartments (other than SF_6) the test shall be made with the original fluid at its filling pressure (±10 %);
– for environmental reasons, it is recommended to replace SF_6 with air at the filling pressure (±10 %).

NOTE 1 Test results with air instead of SF_6 are considered to be representative.

NOTE 2 Nitrogen at the filling pressure (±10 %) is also considered a substitute for SF_6 [9].

NOTE 3 It is assumed that the physical dimensions of the test laboratory are large enough to prevent hot gas reflection towards the indicators.

7.101.4 Indicators (for assessing the thermal effects of the gases)

7.101.4.1 General

Indicators are pieces of black cotton cloth so arranged that their cut edges do not point toward the test object.

Black cotton-interlining lawn (approximately 40 g/m^2) shall be used for indicators.

NOTE Cotton-interlining lawn (approximately 40 g/m^2) is considered to represent light summer wear of the general public.

Care shall be taken that glowing particles do not accumulate. This is achieved if the indicators are mounted without a frame (refer to Figure 3).

The indicator dimensions shall be 150 mm × 150 mm ($^{+15}_{0}$ mm).

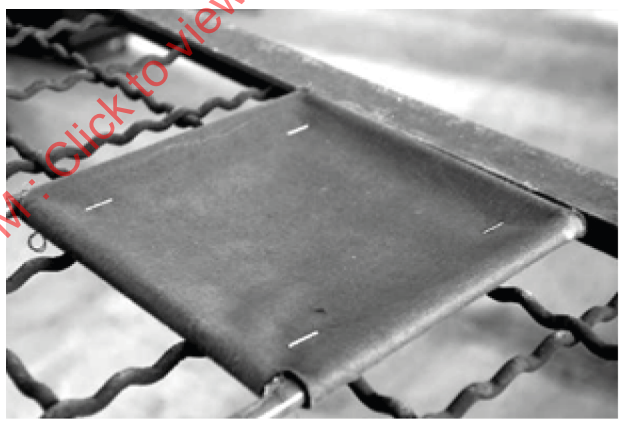


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Figure 3 – Horizontal indicator

Figure 3 provides an indication of a typical arrangement of a horizontal indicator.

7.101.5 Arrangement of indicators

Indicators shall be arranged horizontally, at the rated approach distance (±50 mm) below the lowest point of the test object. The indicators shall cover the whole area of a 3 m × 3 m square frame centered about the test object. They shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area (refer to Figure 2 and Figure 3).

The indicators may be located at any convenient height above the ground allowing for the control box and/or electrical/mechanical linkages if applicable. If the control box's location is

not fully located under the 3 000 mm × 3 000 mm indicator area (refer to Figure 2), then an additional indicator screen 1 000 mm × 1 000 mm shall be positioned above the mounting position of the control box. The additional screen shall be in the same plane as the 3 000 mm × 3 000 mm indicator screen and centered as detailed in Figure 2.

NOTE 1 The additional screen is used to determine if the operators standing position, when in front of the control box, is adequately protected from hot gases and flame.

NOTE 2 This test covers the verification of the protection of both authorized personnel and general public beneath the apparatus.

7.101.6 Test parameters

7.101.6.1 General

A test performed at a given voltage, current and duration is generally valid for all lower values of current, voltage and duration.

7.101.6.2 Voltage

The test shall be performed at any suitable voltage up to and including the rated voltage U_r. If a voltage lower than U_r is chosen, the following conditions shall be met.

a) the current during the test as computed by a digital recording device complies with current requirements of 7.101.6.3.1;

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 not 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 7.101.6.3.1 in the relevant phase.

7.101.6.3 Current

7.101.6.3.1 AC component

The test current shall be set within a ±5 % tolerance of the rated arc fault current (I_A, 87 % I_A or I_{Ae}) as appropriate. If the applied voltage is equal to U_r, this tolerance applies 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^2t) 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.

NOTE Information about the relationship between type of neutral earthing and the single-phase-to-earth arc fault current is provided in 9.101.6.

7.101.6.3.2 Peak current

The instant of closing for a three-phase test 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 U_r, 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 60 Hz) the RMS value of the AC component defined in 7.101.6.3.1 with a tolerance of $^{+5}_{0}$ %.

If the voltage is lower than U_r, the peak value of the prospective current is irrelevant, but the peak value of the short-circuit current for the switchgear and controlgear under test shall not drop below 90 % of the rated peak value.

For higher DC time constants than the standard defined 45 ms of the feeding network, 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.

In case of two-phase initiation of the arc, or single-phase-to-earth the instant of closing shall be chosen to provide the maximum possible DC component.

7.101.6.3.3 Frequency

Tests performed at 50 Hz are also applicable for 60 Hz and vice a versa. At a rated frequency of 50 Hz or 60 Hz, the frequency at the beginning 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 %. The peak factor requirement of subclause 7.101.6.3.2 shall be met as appropriate.

7.101.7 Test procedure

7.101.7.1 Supply circuit

7.101.7.1.1 Three-phase tests

The supply circuit shall be three-phase and all three-phases of the switchgear and controlgear shall be energised. The neutral point of the supply circuit may be either isolated, solidly earthed or earthed through an impedance. Any of these test configurations cover all in service neutral arrangements.

7.101.7.1.2 Single-phase tests

One terminal of the supply circuit shall be connected to the earthing point provided on the switchgear and controlgear, the other to the phase under test.

NOTE Single-phase compartments and single-phase enclosures will only have the one phase under test as defined in Table 2.

In the case of three-phase switchgear and controlgear or single-phase switchgear and controlgear intended to be used in a three-phase network, the two remaining phases of the test object, shall be energised at $U_r/\sqrt{3}$, which may be supplied from a separate voltage source and need not be synchronised. The separate source(s) may be low power and are not intended to supply any significant short-circuit current in case of ignition. If a separate source is used, the remaining two phases can be energised from the same single-phase voltage source. If either of the remaining phases ignites or the voltages collapse, the test shall be repeated as a three-phase internal arc test.

7.101.7.1.3 Phase-to-phase tests

Two phases of the three-phase supply circuit shall be connected to the two adjacent phases of the test object. 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. The one remaining phase of the test object, shall be energised at $U_r/\sqrt{3}$, which may be supplied from a separate voltage source and need not be synchronised. The separate source(s) may be low power and are not intended to supply any significant short-circuit current in case of ignition. If the one remaining phase ignites or the voltage collapses, the test shall be repeated as a three-phase internal arc test.

7.101.7.1.4 Test supply connection direction

The test supply connection direction shall be as follows:

– from the supply connection terminals, through the main switching device with this device in the closed position;
– for an enclosure with several main circuit components inside: supply through one available set of connection terminals, with all switching devices in closed position, except for earthing switches, if any, which shall remain in open position.

7.101.7.2 Arc initiation

7.101.7.2.1 General

The arc shall be initiated by means of a copper wire of about 0,5 mm in diameter.

The point of initiation shall be located at the furthest point, downstream in the current path from the supply, within the high-voltage compartment under test. If the main circuit of the high-voltage compartment under test includes current limiting devices (e.g. fuses), the point of initiation shall be chosen upstream from these limiting devices.

In the case of non-symmetrical designs, the most onerous internal arc initiation should be determined, with respect to arc energy and burn through.

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 2, according to the construction of the enclosure under test.

NOTE Refer to Figure 4 and examples in 7.101.7.2.5.

Inside the enclosure 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 or insulating partitions;
b) when a) is not applicable, by perforation or partial removal of solid insulation from the internal conductors.

7.101.7.2.2 Three-phase arc initiation

The arc shall be initiated between all the phases under test.

7.101.7.2.3 Single-phase arc initiation

In the case of single-phase-to-earth ignition, the arc shall be initiated between the phase and closest earth (single-phase). In the case of a three-phase switchgear and controlgear the arc shall be initiated between the middle phase and closest earth.

For single-phase high-voltage compartments without any adjacent earthed metallic parts, a path for the arc initiating fuse wire shall be created to the closest earthed metallic part.

7.101.7.2.4 Phase-to-phase arc initiation

In the case of a phase-to-phase ignition, the arc shall be initiated between the middle phase and one of the adjacent phases (phase-to-phase). The manufacturer may choose to perform a three-phase arc initiation test with any three-phase enclosure construction in place of the specified test in Table 2.

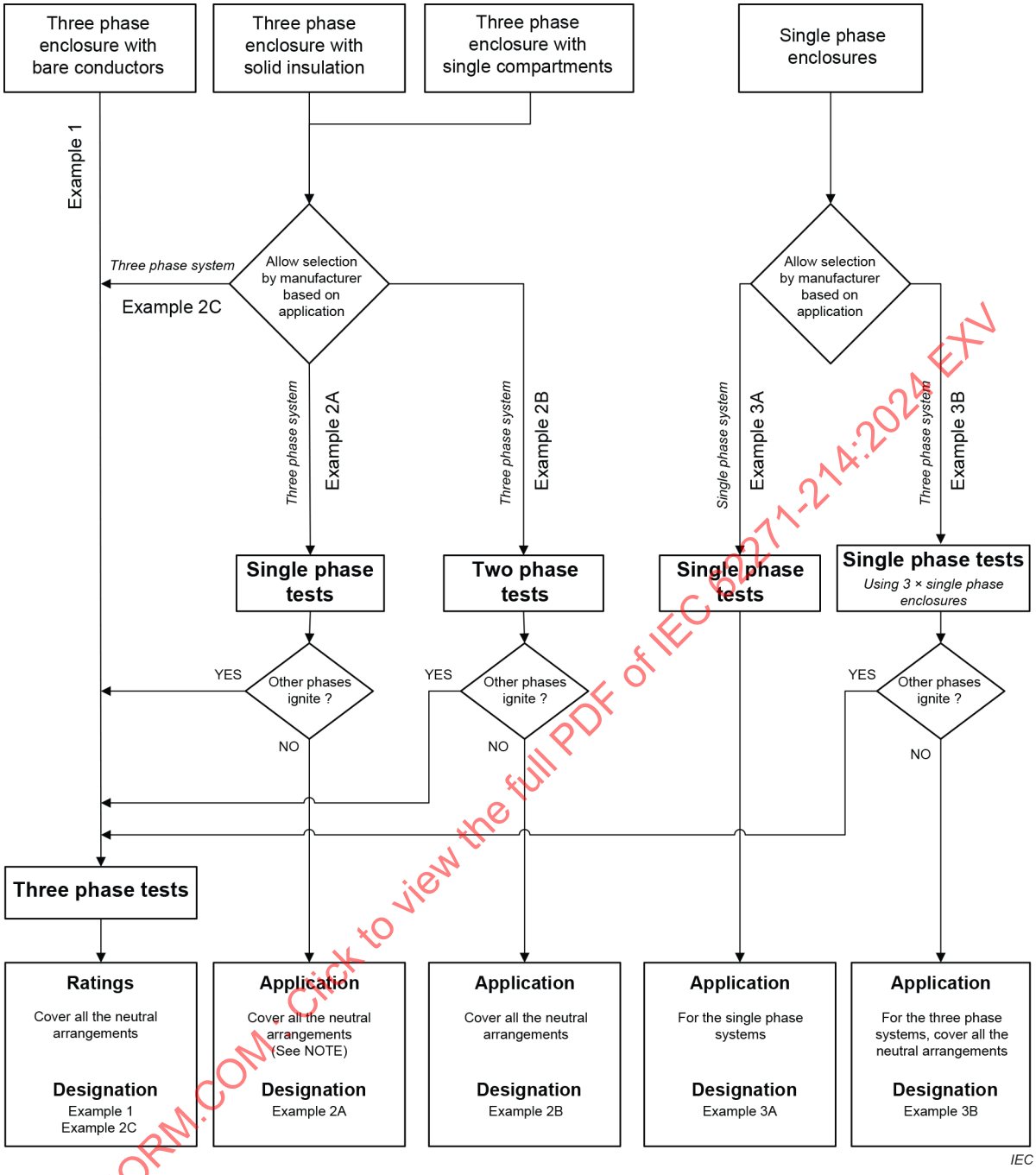
Table 2 – Parameters for internal arc fault test according to enclosure and compartment construction

		Test current	Number of phases/earth for arc initiation	Action if other phase affected
Three-phase enclosures:	With bare conductors	I_A	Three-phase	N/A
	Conductors with solid insulation	87 % I_A	Two	Repeat as three-phase test
		I_{Ae}	One phase and earth	
Single-phase compartments inside three-phase enclosure:		87 % I_A	Two	Repeat as three-phase test
		I_{Ae}	One phase and earth	
Single-phase enclosure (s):		I_{Ae}	One phase and earth	Repeat as three-phase test if single-phase enclosures are tested in a three-phase configuration

NOTE More details about arc initiation according the construction can be found in 7.101.7.2.5.

7.101.7.2.5 Arc initiation according to different construction types

Table 2 provides the parameters for an internal arc fault test according to enclosure and compartment construction. To further clarify the different test methods, refer to Figure 4 and examples in this subclause.



NOTE For systems with an isolated neutral, in the unlikely occurance of a double earth fault within the switchgear and controlgear (two phases fail to earth), then fault levels up to 87 % of the three-phase rated current might occur, and as such, a phase-to-phase fault might be a preferred option taken by the manufacturer.

Figure 4 – Flow-chart for the choice of arc initiation depending on the construction

a) Example 1: A pole-mounted switchgear and controlgear, with bare conductors, tested for a three-phase fault current (RMS) of 12,5 kA, for 0,5 s, intended to be installed on a pole, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s;

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network;

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

b) Example 2: For a three-phase enclosure with solid insulated conductors with the three-phase switchgear and controlgear intended to be suitable for a 12,5 kA 3 phase network (An IAC rating of 12,5 kA for 0,5 s) the manufacturer may choose either a phase-to-phase test or a phase-to-earth test as indicated in the following:

NOTE In this example there is only one three-phase compartment/enclosure, so no other 3 phase tests will be performed.

Example 2A: Manufacturer chooses to perform a phase-to-earth test and ensure it is suitable for all Neutral earth networks by testing with 100 % of the three-phase rated arc fault current: Test performed on a three-phase enclosure with conductors with solid insulation.

IAC;

Arc fault current 12,5 kA assessed with a phase-to-earth test (100 % of the rated single-phase-to-earth arc fault current);

Arc fault duration 0,5 s.

Second and third phase energized during the tests but not affected. In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

Designation: IAC 12,5 kA, 0,5 s (I_{Ae} = 12,5 kA).

Example 2B: Instead manufacturer chooses to perform a phase-to-phase test on a three-phase enclosure with conductors with solid insulation.

IAC;

Arc fault current 10,875 kA assessed with a phase-to-phase test;

Arc fault duration 0,5 s.

Third phase energized during the tests, but not affected.

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

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

Example 2C: The manufacturer chooses to perform a three-phase test independent of the type of three-phase switch conductor system. A pole-mounted switchgear and controlgear, tested for a three-phase fault current (RMS) of 12,5 kA, for 0,5 s, intended to be installed on a pole, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

In this case the device may be installed in any neutral earth configuration three-phase 12,5 kA network.

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

c) Example 3:

Example 3A: A single-phase enclosure pole-mounted switchgear and controlgear tested for a phase-to-earth fault current (RMS) of 12,5 kA, for 0,5 s, in a single-phase system, is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

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

A single-phase enclosure pole-mounted switchgear and controlgear tested in a single-phase system shall not be IAC classified for a three-phase system.

Example 3B**:** Three independent single-phase pole-mounted switchgear and controlgear enclosures tested for a phase-to-earth fault current (RMS) of 12,5 kA, for 0,5 s, in a three-phase system is designated as follows:

IAC;

Arc fault current 12,5 kA;

Arc fault duration 0,5 s.

Designation: IAC 12,5 kA, 0,5 s (I_{Ae} = 12,5 kA).

7.101.8 Criteria to pass the test

IAC designation is demonstrated for the pole-mounted switchgear and controlgear if the following criteria are met:

a) Criterion No. 1

- No fragmentation of the enclosure occurs.
- No ejection of fragments or of other parts of the switchgear of an individual mass of 60 g or more, occur.

Deformations are accepted.

The switchgear and controlgear does not need to comply with its IP code after the test.

b) Criterion No. 2

Arcing does not cause holes in the enclosure under test. Holes in the enclosure which are created after the duration of the test by other effects than burning through, are disregarded.

The inclusion of a pressure relief vent and its operation is permitted and is not deemed as a structural failure; however, any ejected parts due to its operation shall comply with the 60 g limit for ejected parts.

c) Criterion No. 3

Indicators do not ignite during the test and within 1 s after the current duration. If indicators have been ignited 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 or burning liquids, 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 burning paint or stickers are also excluded.

d) Criterion No. 4

The switchgear and controlgear 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. To check the continuity, verify by testing with 30 A (DC) to the earthing point provided. The voltage drop shall be lower than 3 V.

7.101.9 Transferability of the test results

The validity of the results of a test carried out in a tested enclosure of a particular design of pole-mounted switchgear and controlgear can be extended to another test enclosure provided

that the original test was more onerous and this other test enclosure can be considered as similar to the tested unit in the following aspects:

– mounting height of test enclosure with respect to the indicator positions;
– structure and strength of the enclosure;
– performance of the pressure relief device, if any;
– insulation system;
– physical influences (pressure rise, gas flow and thermal effects).

NOTE IEC TR 62271-307[3] can be used as a reference.

8 Routine tests

Not applicable.

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

Subclauses of Clause 9 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 not mentioned below are not applicable for this document.

9.1 General

Subclause 9.1 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is replaced by following text:

Pole-mounted switchgear and controlgear have been constructed in various forms that have evolved with changing technologies and functional requirements. The selection of pole-mounted switchgear and controlgear essentially involves an identification of the functional requirements for the service installation.

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

9.101 Internal arc fault

9.101.1 General

If the switchgear and controlgear is installed, operated and maintained in accordance with the instructions of the manufacturer, there should be low probability that an internal arc occurs, but it cannot be completely disregarded. Failure within the enclosure of pole-mounted switchgear and controlgear due either to a defect or exceptional operating conditions or maloperation can initiate an internal arc, which constitutes a hazard, if persons are present.

When selecting pole-mounted switchgear and controlgear, 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, risk is the combination of the probability of occurrence of harm and the severity of the harm. (Refer to Clause 5 of ISO/IEC Guide 51:2014 on the concept of safety.[4])

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 [4]. This procedure is based on the assumption that the user has a role to play in the risk reduction.

9.101.2 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 3 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 applicable preventive measures to the installation, commissioning, operation and maintenance.

Table 3 – 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)
Connections (Inside the enclosure)	Inadequate design	Selection of adequate dimensions Use of appropriate materials
	Faulty assembly	Checking of workmanship and/or dielectric test on site.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of fluid levels, where applicable
Disconnectors Switches Earthing switches	Maloperation	Interlocks. 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
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 for example, protection cover, low-voltage fuses
Circuit-breakers	Insufficient maintenance	Regular programmed maintenance Instructions to personnel
All locations	Error by personnel	Limitation of access by compartmentalisation. 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. Use of sealed compartments
	Overvoltages	Surge protection. Adequate insulation co-ordination. Dielectric tests on site

9.101.3 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 can be adopted to provide protection to persons in case of an internal arc. These measures are aimed to limit the external consequences of such events.

Following are some examples of these measures:

– rapid fault clearance times initiated by detectors sensitive to light, pressure or heat;

– application of suitable fuses in combination with switching devices to limit the let-through current and fault duration;
– fast elimination of arc by diverting it to metallic short circuit by means of fast-sensing and fast-closing devices;
– remote operation instead of operation at the base of the switchgear and controlgear;
– pressure-relief device.

9.101.4 Considerations for the selection and installation

The user shall make a selection, taking into account the characteristics of the network, operating procedures and service conditions.

As a guide for the selection of the adequate switchgear and controlgear with respect to internal arcs, the following criteria can be used:

– where the risk is considered negligible, IAC designated switchgear and controlgear is not necessary;
– where the risk is considered to be relevant, IAC designated switchgear and controlgear 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 protection of persons in case of an internal arc is not only a matter of design and IAC designation of the switchgear and controlgear but depends also on the installation conditions. Internal arc faults inside pole-mounted switchgear and controlgear 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 can produce hot decomposition products, either gaseous or vaporous, which can be discharged to the outside of the enclosure. Therefore, appropriate measures should be considered for the installation site.

For pole-mounted switchgear and controlgear, the minimum installation height of the enclosure of the high-voltage is based on the rated approach distance declared by the manufacturer plus 2 m.

9.101.5 Internal arc test

The internal arc test is intended to verify the effectiveness of the design in protecting persons in case of an internal arc, during normal operating condition. The test does not assess the behaviour of the switchgear and controlgear 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 applicable to pole-mounted switchgear and controlgear, to which an Internal Arc Classification is to be assigned.

NOTE 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 what arc duration is permissible with a lower test current.

9.101.6 IAC designation

IAC designation indicates a tested level of protection of persons under normal operating condition as stated in 7.101.2. It is concerned with personnel protection under these conditions; it is not concerned with personnel protection under maintenance conditions nor with service continuity.

The pole-mounted switchgear and controlgear will be designated as follows.

– General: designation IAC (acronym for Internal Arc Classification).

– Rated values: arc fault current in kiloamperes (kA), and duration in seconds (s) (according to 7.101.6). Single-phase values can be assigned to switchgear and controlgear, having one or more high-voltage compartments where its construction will prevent the arc from becoming multiphase, as demonstrated during the internal arc test. The relationship between neutral earthing and single-phase-to-earth arc fault current is given in Table 4. 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 can accept a lower value, depending on the neutral earthing.

Table 4 – 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 switchgear and controlgear have a very low probability. Therefore, this condition could not be applicable and the user can specify a reduced single-phase-to-earth arc fault current rating. NOTE 3 Resonant earthed (neutral) systems are covered in this table by the term "isolated neutral".	

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

Clause 10 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable for this document, except 10.1 which is replaced as follows.

10.1 General

When enquiring about or ordering an installation of IAC specified pole-mounted switchgear and controlgear the IAC pole-mounted designation, rated approach distance, arc fault currents and duration should be included.

11 Transport, storage, installation, operation instruction and maintenance

Clause 11 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable for this document, except 11.1, 11.2 and 11.3 which are replaced as follows.

11.1 General

It is essential that the transport, storage and installation of switchgear and controlgear, as well as their operation and maintenance in service, be performed in accordance with instructions given by the manufacturer.

11.2 Conditions during transport, storage and installation

A special agreement should be made between manufacturer and user if the service conditions of temperature and humidity defined in the order cannot be guaranteed during transport, storage and installation. Special precautions may be essential for the protection of insulation during transport, storage and installation, and prior to energizing, to prevent moisture absorption due, for instance, to rain, snow or condensation. Vibrations during transport shall be considered. Appropriate instructions should be provided by the manufacturer.

11.3 Installation

11.3.1 General

For IAC classified switchgear and controlgear, guidance on safe installation conditions for the case of an internal arc should be provided. The hazards of the actual installation condition should be assessed with respect to installation conditions validated during the internal arc classification (refer to 7.101). However, if the purchaser (user) considers that the risk is not relevant, the switchgear and controlgear can be installed without the restrictions indicated by the manufacturer. The minimum installation height is the declared rated approach distance plus 2 m.

11.101 Maintenance

Where necessary, the manufacturer shall provide guidance on any maintenance requirements in order to maintain the integrity of the IAC designation over the life of the product. Refer to the sections of Table 3 as examples where maintenance can be considered over the life of the switchgear and controlgear.

12 Safety

Clause 12 of IEC 62271-1:2017 is not applicable for this document except 12.1 modified as follows:

12.1 General

As far as the protection of persons is concerned, the correct performance of the pole-mounted switchgear and controlgear in the event of an internal arc is not only a matter of design of the equipment itself, but also of the installation conditions, operating procedure and if applicable maintenance procedures, for instance, see 9.101.

13 Influence of the product on the environment

Clause 13 of IEC 62271-1:2017 and IEC 62271-1:2017/AMD1:2021 is not applicable for this document and is replaced as follows:

The manufacturer shall be prepared to provide on request, relevant information about the environmental impact of the switchgear and controlgear. The manufacturer shall give guidance on request, concerning disassembly and end-of-life procedures for the different materials and components of the equipment and indicate recycling suitability.

Annex A
(normative)

Identification of the test objects

A.1 General

For identification of a test object, the following topics shall be covered.

A.2 Data

– Manufacturer's name;
– Type designation, ratings and unique identifier of test object;
– Outline description of test object (including number of poles, interlocking system, busbar system, earthing system, and the arc extinguishing process);
– Make, type, and ratings of essential parts, where applicable (for example, drive mechanisms, interrupters, shunt impedances, relays, fuse links, insulators);
– Rated characteristics of fuse links and protective devices;
– Whether the apparatus is intended for operation in the vertical and horizontal plane;
– Mock-ups (if used) details shall also be given.

A.3 Drawings

Drawings to be submitted	Drawing content (as applicable)
Single-line diagram of main circuit	Type designation of principal components
General layout NOTE For an assembly it can be necessary to provide drawings of the complete assembly and of each switching device.	Overall dimensions Supporting structure and mounting points Enclosure(s) Pressure-relief devices Conducting parts of main circuit Earthing conductors and earthing connections Electrical clearances: to earth, between open contacts; between poles. Location and dimensions of barriers between poles Location of earthed metallic screens, shutters or partitions in relation to live parts Liquid insulation level Location and type designation of insulators Location and type designation of instrument transformers
Detailed drawings of insulators	Material Dimensions (including profile and creepage distances)
Arrangement drawings of cable boxes	Electrical clearances Principal dimensions Terminals Level or quantity and specifications of insulant in filled boxes Cable termination details

Bibliography

[1] IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Part 601: Generation, transmission and distribution of electricity – General*
IEC 60050-601:1985/AMD1:1998
IEC 60050-601:1985/AMD2:2020

[2] IEC 62271-200:2021, *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*

[3] 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*

[4] ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

[5] CIGRE TECHNICAL BROCHURE 686:2017, *Mitigating the effects of arcs in M.V. Switchgear*

[6] IEC 60038:2009, *IEC standard voltages*
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[7] IEC 60059:1999, *IEC standard current ratings*
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[8] IEC 60050-466:1990, *International Electrotechnical Vocabulary (IEV) – Part 466: Overhead lines*
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[9] CIGRE TECHNICAL BROCHURE 602:2014, *Tools for the Simulation of the Effects of the Internal Arc in Transmission and Distribution Switchgear*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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APPAREILLAGE À HAUTE TENSION –

Partie 214: Classification arc interne des appareillages sous enveloppe métallique à courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV montés sur poteau

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L'IEC 62271-214 a été établie par le sous-comité 17C: Ensembles, du comité d'études 17 de l'IEC: Appareillage haute tension. Il s'agit d'une Norme internationale.

Cette deuxième édition annule et remplace la première édition parue en 2019. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour du positionnement des indicateurs;
b) connexion de mise à la terre du neutre du circuit d'essai pour les essais triphasés;
c) révision générale à des fins de cohérence avec l'IEC 62271-200 Éd.3.0:2021.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
17C/924/FDIS	17C/931/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

La version française de cette norme n'a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Cette norme doit être lue conjointement avec l'IEC 62271-1, deuxième édition, parue en 2017, à laquelle elle fait référence et qui s'applique sauf spécification contraire dans la présente norme. Afin de simplifier l'indication des exigences correspondantes, la numérotation des articles et paragraphes reprend celle de l'IEC 62271-1. Les amendements de ces articles et paragraphes sont indiqués sous les mêmes références, tandis que les paragraphes supplémentaires sont numérotés à partir de 101. Tout article qui comprend le terme "Non applicable" indique que l'article ne s'applique pas à l'IEC 62271-214, mais ne présume pas que l'article s'applique ou non à la norme d'appareillage applicable.

Une liste de toutes les parties de la série IEC 62271, publiées sous le titre général *Appareillage à haute tension*, se trouve sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

INTRODUCTION

L'IEC 62271-214 a été établie à la suite de la demande de supprimer de l'IEC 62271-200 les appareillages montés sur poteau classifiés arc interne (IAC) selon le Type C. L'IEC 62271-214 doit être considérée comme indépendante de l'IEC 62271-200. Toutefois elle reste reliée aux autres normes de produits de la série IEC 62271.

Seuls les appareillages à bornes ouvertes montés sur poteau sont pris en compte dans le présent document.

Ces équipements se rapportent aux systèmes triphasés, biphasés et monophasés.

APPAREILLAGE À HAUTE TENSION –

Partie 214: Classification arc interne des appareillages sous enveloppe métallique à courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV montés sur poteau

1 Domaine d'application

La présente partie de l'IEC 62271 spécifie les exigences relatives à la classification arc interne des appareillages sous enveloppe métallique à courant alternatif montés sur poteau, de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV, et de fréquences de service inférieures ou égales à 60 Hz.

Le présent document s'applique aux équipements à bornes ouvertes triphasés, biphasés et monophasés auxquels une classification arc interne est attribuée. Les enveloppes peuvent comprendre des composants fixes et amovibles et peuvent être remplies de fluide (liquide ou gaz) pour l'isolation.

NOTE 1 La classification IAC tient compte de la disposition de l'installation des appareillages à haute tension et de la zone opérationnelle du travailleur.

NOTE 2 Pour l'utilisation du présent document, la haute tension (IEC 60050-601:1985, 601-01-27) est la tension assignée supérieure à 1 000 V. Cependant, la moyenne tension (IEC 60050-601:1985, 601-01-28) est communément utilisée pour les réseaux de distribution avec des tensions supérieures à 1 kV et est généralement appliquée pour des tensions inférieures ou égales à 52 kV; se reporter à [1][1].

Le présent document n'exclut pas que d'autres équipements puissent être inclus dans la même enveloppe. Dans ce cas, toute influence possible dudit équipement sur l'appareillage doit être prise en compte.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-151:2001, *Vocabulaire Électrotechnique International (IEV) – Partie 151: Dispositifs électriques et magnétiques*
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014
IEC 60050-151:2001/AMD3:2019
IEC 60050-151:2001/AMD4:2020
IEC 60050-151:2001/AMD5:2021

IEC 60050-441:1984, *Vocabulaire Électrotechnique International (IEV) – Partie 441: Appareillage et fusibles*
IEC 60050-441:1984/AMD1:2000

[1] Les chiffres entre crochets renvoient à la Bibliographie.