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High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

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IEC 62271-100 edition 3.1 contains the third edition (2021-07) [documents 17A/1299/FDIS and 17A/1305/RVD], its corrigendum 1 (2021-12 (applies only to the French version), its corrigendum 2 (2022-07), its corrigendum 3 (2024-01), and its amendment 1 (2024-08) [documents 17A/1406/FDIS and 17A/1410/RVD].

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

International Standard IEC 62271-100 has been prepared by subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear.

This third edition cancels and replaces the second edition published in 2008, Amendment 1:2012 and Amendment 2:2017. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– the document has been updated to IEC 62271-1:2017;
– Amendments 1 and 2 have been included;
– the definitions have been updated, terms not used have been removed;
– Subclauses 7.102 through 7.108 have been restructured.

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

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

This document is to 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 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.

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

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION to Amendment 1

This amendment includes the following significant changes:

In IEC 62271-100:2021 there is a slight difference for the calculation of u_c for T10 in Table 20 and Table 21. The u_c value for T10 shall be the same for k_{pp} 1,3 and k_{pp} 1,5 because both conditions also cover transformer limited faults. For voltage ratings higher than 170 kV u_c also covers cases of three-phase line faults with effectively earthed neutral systems. See also the notes in Table 20 and Table 21. By increasing the k_{af} from 1,76 to 1,765 the u_c values are practically the same again for k_{pp} 1,3 and k_{pp} 1,5.

Furthermore:

– The definition of terminal fault has been updated.
– The description of the time parameters for the rated operated sequence has been updated (the parameters remained the same).
– Rated voltages 15,5; 27 and 40,5 kV added to Table 1.
– Additional criteria for dielectric test added.
– It has been made explicit that partial discharge test only is applicable to GIS and dead-tank circuit-breakers.
– Voltage test as condition check as per 7.2.12.103 added to 7.2.12.101.
– The t_2 for T60 are corrected to the t_2 values of T100.
– TRV values in Table 16, Table 17, Table 18, Table 19, Table 20, Table 22, Table 23, Table 24, Table 25, Table 30 and Table F.1 have been recalculated and updated.
– Requirement on having inrush making current in the same phase as minimum arcing times during three-phase back-to-back capacitor bank current tests.
– Requirement to perform mechanical operating tests on all releases added.
– Existing tolerance for single-phase and double-earth fault added to Table B.1.
– Tolerance for breaking current L_{75} updated in Table B.1.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

1 Scope

This part of IEC 62271 is applicable to three-phase AC circuit-breakers designed for indoor or outdoor installation and for operation at frequencies of 50 Hz and/or 60 Hz on systems having voltages above 1 000 V. This document includes only direct testing methods for making-breaking tests. For synthetic testing methods refer to IEC 62271-101.

NOTE In a direct testing method one source is used to supply the voltage and current during the making and breaking tests.

This part of IEC 62271 is not applicable to:

– circuit-breakers with a closing mechanism for dependent manual operation;
– circuit-breakers intended for use on motive power units of electrical traction equipment; these are covered by IEC 60077 (all parts) [1][1];
– generator circuit-breakers installed between generator and step-up transformer; these are covered by the IEC 62271-37-013 [2];
– self-tripping circuit-breakers with tripping devices that cannot be made inoperative during testing. Tests on automatic circuit reclosers are covered by IEC 62271-111 [3];
– tests to prove the performance under abnormal conditions that are not described in this document are subject to agreement between manufacturer and user. Such abnormal conditions are, for example, cases where the voltage is higher than the rated voltage of the circuit-breaker, conditions which can occur due to sudden loss of load on long lines or cables.

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

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

IEC 60050-442:1998, *International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories*
IEC 60050-442:1998/AMD1:2015
IEC 60050-442:1998/AMD2:2015
IEC 60050-442:1998/AMD3:2019

IEC 60050-461:2008, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables*

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

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

IEC 60059, *IEC standard current ratings*

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

IEC 60255-151:2009, *Measuring relays and protection equipment – Part 151: Functional requirements for over/under current protection*

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

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

IEC 62271-101, *High-voltage switchgear and controlgear – Part 101: Synthetic testing*

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

IEC 62271-200:20—[2], *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

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

IEC 62271-100 edition 3.1 contains the third edition (2021-07) [documents 17A/1299/FDIS and 17A/1305/RVD], its corrigendum 1 (2021-12 (applies only to the French version), its corrigendum 2 (2022-07), its corrigendum 3 (2024-01), and its amendment 1 (2024-08) [documents 17A/1406/FDIS and 17A/1410/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 62271-100 has been prepared by subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear.

This third edition cancels and replaces the second edition published in 2008, Amendment 1:2012 and Amendment 2:2017. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– the document has been updated to IEC 62271-1:2017;
– Amendments 1 and 2 have been included;
– the definitions have been updated, terms not used have been removed;
– Subclauses 7.102 through 7.108 have been restructured.

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

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

This document is to 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 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.

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

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION to Amendment 1

This amendment includes the following significant changes:

In IEC 62271-100:2021 there is a slight difference for the calculation of u_c for T10 in Table 20 and Table 21. The u_c value for T10 shall be the same for k_{pp} 1,3 and k_{pp} 1,5 because both conditions also cover transformer limited faults. For voltage ratings higher than 170 kV u_c also covers cases of three-phase line faults with effectively earthed neutral systems. See also the notes in Table 20 and Table 21. By increasing the k_{af} from 1,76 to 1,765 the u_c values are practically the same again for k_{pp} 1,3 and k_{pp} 1,5.

Furthermore:

– The definition of terminal fault has been updated.
– The description of the time parameters for the rated operated sequence has been updated (the parameters remained the same).
– Rated voltages 15,5; 27 and 40,5 kV added to Table 1.
– Additional criteria for dielectric test added.
– It has been made explicit that partial discharge test only is applicable to GIS and dead-tank circuit-breakers.
– Voltage test as condition check as per 7.2.12.103 added to 7.2.12.101.
– The t_2 for T60 are corrected to the t_2 values of T100.
– TRV values in Table 16, Table 17, Table 18, Table 19, Table 20, Table 22, Table 23, Table 24, Table 25, Table 30 and Table F.1 have been recalculated and updated.
– Requirement on having inrush making current in the same phase as minimum arcing times during three-phase back-to-back capacitor bank current tests.
– Requirement to perform mechanical operating tests on all releases added.
– Existing tolerance for single-phase and double-earth fault added to Table B.1.
– Tolerance for breaking current L_{75} updated in Table B.1.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

1 Scope

This part of IEC 62271 is applicable to three-phase AC circuit-breakers designed for indoor or outdoor installation and for operation at frequencies of 50 Hz and/or 60 Hz on systems having voltages above 1 000 V. This document includes only direct testing methods for making-breaking tests. For synthetic testing methods refer to IEC 62271-101.

NOTE In a direct testing method one source is used to supply the voltage and current during the making and breaking tests.

This part of IEC 62271 is not applicable to:

– circuit-breakers with a closing mechanism for dependent manual operation;
– circuit-breakers intended for use on motive power units of electrical traction equipment; these are covered by IEC 60077 (all parts) [1][1];
– generator circuit-breakers installed between generator and step-up transformer; these are covered by the IEC 62271-37-013 [2];
– self-tripping circuit-breakers with tripping devices that cannot be made inoperative during testing. Tests on automatic circuit reclosers are covered by IEC 62271-111 [3];
– tests to prove the performance under abnormal conditions that are not described in this document are subject to agreement between manufacturer and user. Such abnormal conditions are, for example, cases where the voltage is higher than the rated voltage of the circuit-breaker, conditions which can occur due to sudden loss of load on long lines or cables.

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

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

IEC 60050-442:1998, *International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories*
IEC 60050-442:1998/AMD1:2015
IEC 60050-442:1998/AMD2:2015
IEC 60050-442:1998/AMD3:2019

IEC 60050-461:2008, *International Electrotechnical Vocabulary (IEV) – Part 461: Electric cables*

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

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

IEC 60059, *IEC standard current ratings*

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

IEC 60255-151:2009, *Measuring relays and protection equipment – Part 151: Functional requirements for over/under current protection*

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

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

IEC 62271-101, *High-voltage switchgear and controlgear – Part 101: Synthetic testing*

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

IEC 62271-200:20—[2], *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

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

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2 Under preparation. Stage at the time of publication: IEC RFDIS 62271-200:2021.