

INTERNATIONAL STANDARD

IEEE Std C37.60™

NORME INTERNATIONALE



**High-voltage switchgear and controlgear –
Part 111: Automatic circuit reclosers for alternating current systems up to and
including 38 kV**

**Appareillage à haute tension –
Partie 111: Disjoncteurs à réenclenchement de circuit automatique pour
systèmes en courant alternatif jusqu'à 38 kV compris**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 111: Automatic circuit reclosers for alternating current systems up to and including 38 kV

FOREWORD

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This third edition cancels and replaces the second edition, published in 2012, and constitutes a technical revision. The main changes with respect to the previous edition are as follows:

- a) Deletion of the fault interrupter from the title, scope and body of the standard including the original Annex G. IEEE will develop a separate standard for this type of equipment used primarily in North America to be designated as IEEE C37.62;
- b) Adoption of IEC 62271-1:2017 as a normative reference replacing both IEEE C37.100.1-2007 and IEC 62271-1:2007;
- c) Adoption of the “standard test method” for the conduction of wet tests for both IEEE and IEC voltage ratings, reference 7.2.7.2 and Tables 2 and 3;
- d) Line and cable charging tests in 7.101.6: added test voltage level requirements;
- e) Added test specifications in 7.103.3 and 7.103.5 for effectively earthed neutral systems (first-pole-to-clear factor $k_{pp} = 1,3$) making this an optional rating. The k_{pp} parameters are used in lieu of the system terms;
- f) Added low current tests in 7.104 as a replacement of the critical current tests;
- g) Adopted the revised allowable temperature rise table of IEC 62271-1:2017 with an increase in the allowable temperature rise for certain points in non-oxidizing gases (NOG);
- h) Time-current test requirements in 7.108: several changes including increased number of test current levels and tests at each level. Specified minimum number of curves to be tested;
- i) Mechanical duty tests in 7.109: added requirements for testing at high and low temperature;
- j) Replaced normative references IEC 60255-22-1 and IEC 60255-22-4 with IEC 60255-26 in 7.111.1;
- k) Added pass/fail criteria for fault interruption tests with restrikes in 7.112.1;
- l) Added Clauses 9, 10, 11, 12 and 13 similar to those in IEC 62271-1 but tailored to the recloser;
- m) Deleted Annex A: Information and technical requirements to be given with enquiries, tenders and orders.

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

FDIS	Report on voting
17A/1202/FDIS	17A/1207/RVD

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

International standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

This standard is to be read in conjunction with IEC 62271-1:2017, 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.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 111: Automatic circuit reclosers for alternating current systems up to and including 38 kV

1 Scope

This part of IEC 62271 applies to all overhead, pad-mounted, dry vault and submersible single or multi-pole alternating current automatic circuit reclosers for rated maximum voltages above 1 000 V and up to and including 38 kV.

Devices that require a dependent manual operation are not covered by this document.

In order to simplify this document where possible, the term recloser (or reclosers) has been substituted for automatic circuit recloser(s) or cutout mounted recloser(s) or both.

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.

NOTE In this dual logo standard, normative references are made to both IEEE and IEC standards. In each case, the specifications in two referenced standards have been judged by the Maintenance Team to be technically equal even though the exact wording may be different. Differences in the wording are considered to be editorial only. Where the two standards are not technically equal, the differences are resolved in the text.¹

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

IEC 60050-441, *International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses* (available at: <http://www.electropedia.org>)

IEC 60071-2:2018, *Insulation co-ordination – Part 2: Application guidelines*

IEC 60255-26:2013, *Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements*

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

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

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

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

¹ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement the standard.

IEC 62271-4, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF₆) and its mixtures*

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

IEEE Std 4™, *IEEE Standard Techniques for High-Voltage Testing*

IEEE Std C37.90.1™-2012, *IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*

IEEE Std C37.301™, *IEEE Standard for High-Voltage Switchgear (Above 1 000 V) Test Techniques – Partial Discharge Measurements*

3 Terms and definitions

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

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

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

NOTE Additional terms and definitions are organized so as to be aligned with the classification used in IEC 60050-441.

3.1 General terms

3.1.101

automatic circuit recloser

self-controlled device for making, carrying, and automatically interrupting and reclosing an alternating-current circuit, with a predetermined sequence of opening and reclosing followed by resetting, hold-closed, or lockout operation.

Note 1 to entry: An automatic circuit recloser includes an assembly of control elements required to detect overcurrents and control the recloser operation.

Note 2 to entry: Refer to Annex F for background information of an automatic circuit recloser.

3.1.102

cutout mounted recloser

single-phase automatic circuit recloser mounted in a fuse support or base as defined in IEEE Std C37.40 [1]² and IEC 60282-2 [2]

3.1.103

dry vault

ventilated, enclosed area not subject to flooding

3.1.104

effectively earthed neutral system

system earthed through a sufficiently low impedance such that for all system conditions the ratio of the zero-sequence reactance to the positive-sequence reactance (X_0/X_1) is positive and less than 3, and the ratio of the zero-sequence resistance to the positive-sequence reactance (R_0/X_1) is positive and less than 1

² Numbers in square brackets refer to the Bibliography.

Note 1 to entry: Normally such systems are solidly earthed (neutral) systems or low impedance earthed (neutral) systems.

Note 2 to entry: For the correct assessment of the earthing conditions, not only the physical earthing conditions around the relevant location but the total system is considered.

Note 3 to entry: Throughout this document, the parameter $k_{pp} = 1,3$ is used to denote an effectively earthed neutral system.

[SOURCE: IEC 62271-100:2008, 3.1.128, modified – The second sentence of the definition has become Note 1 to entry.]

3.1.105

non-effectively earthed neutral system

system other than an effectively earthed neutral system (3.1.104)

Note 1 to entry: Normally such systems are isolated neutral systems, high impedance earthed (neutral) systems or resonant earthed (neutral) systems.

Note 2 to entry: For the correct assessment of the earthing conditions, not only the physical earthing conditions around the relevant location but the total system is considered.

Note 3 to entry: Throughout this document, the parameter $k_{pp} = 1,5$ is used to denote a non-effectively earthed neutral system.

[SOURCE: IEC 62271-100:2008, 3.1.129, modified – The second sentence of the definition has become Note 1 to entry.]

3.1.106

pad-mounted reclosers

enclosed reclosers, the exterior enclosure of which is at earth potential, positioned on a surface-mounted pad

Note 1 to entry: This definition is similar to that given in the National Electrical Safety Code® (NESC®) C2-2012 [3] (US).³

Note 2 to entry: The term "pad-mounted enclosure" is also defined in IEEE Std C57.12.28 [4] as follows: "An enclosure containing electrical apparatus, typically located outdoors at ground level where the general public has direct contact with the exterior surfaces of the equipment. The general construction of this equipment is such that authorized personnel may obtain direct access to the apparatus inside the equipment compartment(s)."

3.1.107

publicly accessible

situated in an area where no means are implemented to expressly prevent access and where any person can access without authorization

3.1.108

restrike

<of an AC mechanical switching device> resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of a quarter cycle of power frequency or longer

[SOURCE: IEC 60050-441:1984, 441-17-46]

3.1.109

re-ignition

resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of less than a quarter cycle of power frequency

³ National Electrical Safety Code and NESC are both registered trademarks and service marks of the Institute of Electrical and Electronics Engineers, Inc.

[SOURCE: IEC 60050-441:1984, 441-17-45]

3.1.110
series-trip recloser

recloser in which main-circuit current above a specified value, flowing through a solenoid or operating coil, provides the energy necessary to open the main contacts

Note 1 to entry: This definition for a series-trip recloser originated in IEEE; it is similar to the definition for a self-tripping circuit-breaker in IEC 62271-100.

3.1.111
shunt-trip recloser

recloser in which the tripping mechanism, by releasing the holding means, permits the main contacts to open, with both the tripping mechanism and the contact opening mechanism deriving operating energy from other than the main circuit

3.1.112
submersible

constructed so as to be successfully operable when submerged in water under specified conditions of pressure and time

3.1.113
unit operation

<of a recloser> interrupting operation followed by a closing operation within a specified reclosing interval

Note 1 to entry: The final interruption, after which lockout occurs, is also considered one unit operation.

Note 2 to entry: See Figure 1. See also Annex K for a comparison of terms between IEEE and IEC.

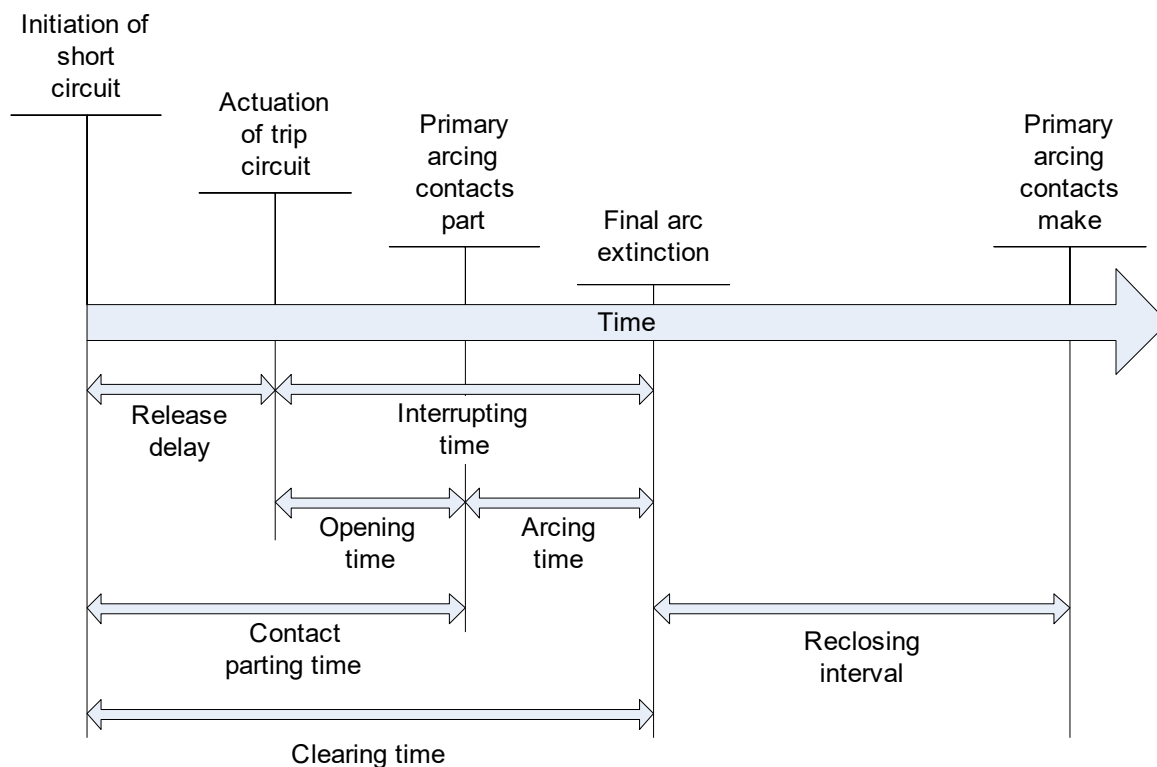


Figure 1 – Unit operation

IEC

3.2 Assemblies of switchgear and controlgear

No particular definitions.

3.3 Parts of assemblies

No particular definitions.

3.4 Switching devices

No particular definitions.

3.5 Parts of switchgear and controlgear

No particular definitions.

3.6 Operation

3.6.101

dependent manual operation

<of a mechanical switching device> operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator

3.6.102

non-reclose

operational setting that blocks the automatic reclose function of a recloser causing it to be on a one-trip-to-lockout sequence

3.6.103

pole discrepancy

time interval, between the first pole contact and the final pole contact to mechanically close or open when three single-pole switchgear devices are configured for three-phase system application.

Note 1 to entry: The time interval is expressed in electrical degrees.

[SOURCE: IEEE C37.66-2005 [5], modified by deleting the reference to capacitor switch.

3.7 Characteristic quantities

3.7.101

cable-charging current

current supplied to an unloaded shielded or belted cable

Note 1 to entry: Cable-charging current is expressed by its r.m.s. value in amperes.

3.7.102

definite-time delay

qualifying term indicating that there is purposely introduced a delay in action, which delay remains substantially constant regardless of the magnitude of the operating quantity that causes the action

3.7.103

inverse-time delay

purposely introduced delay in action, which delay decreases as the magnitude of the operating quantity (that causes the action) increases

3.7.104

line-charging current

current supplied to an unloaded overhead line

Note 1 to entry: Line-charging current is expressed by its r.m.s. value in amperes.

3.7.105

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

[SOURCE: IEC 62271-1:2017,3.1.20]

3.7.106

partial discharge extinction voltage

U_e

applied voltage at which repetitive partial discharges cease to occur in the test object when the voltage applied to the object is gradually decreased from a higher value at which partial discharge pulse quantities are observed

Note 1 to entry: In practice, U_e is the highest applied voltage at which the magnitude of a chosen partial discharge pulse quantity becomes equal to, or less than, a specified low value.

Note 2 to entry: Although worded differently, this IEEE definition is equivalent to IEC 60076-1:2007, 212-11-42.

3.7.107

partial discharge inception voltage

U_i

applied voltage at which repetitive partial discharges are first observed in the test object when the voltage applied to the object is gradually increased from a lower value at which no partial discharges are observed

Note 1 to entry: In practice, U_i is the lowest applied voltage at which the magnitude of a partial discharge pulse quantity becomes equal to or exceeds a specified low value.

Note 2 to entry: Although worded differently, this IEEE definition is equivalent to IEC 60076-1:2007, 212-11-41.

3.7.108

prospective transient recovery voltage

<of a circuit> transient recovery voltage following the breaking of the prospective symmetrical current by an ideal switching device

Note 1 to entry: The definition assumes that the switching device or the fuse, for which the prospective transient recovery voltage is sought, is replaced by an ideal switching device, i.e. having instantaneous transition from zero to infinite impedance at the very instant of zero current, i.e. at the "natural" zero. For circuits where the current can follow several different paths, e.g. a polyphase circuit, the definition further assumes that the breaking of the current by the ideal switching device takes place only in the pole considered.

Note 2 to entry: The terms "inherent transient recovery voltage" and "prospective transient recovery voltage" are often used interchangeably.

[SOURCE: IEC 60050-441:1984, 441-17-29]

3.7.109

reclosing interval

<of an automatic circuit recloser> open-circuit time between an automatic opening and the succeeding automatic reclosure

Note 1 to entry: The IEEE definition for reclosing interval is similar to the definition of "dead time" in IEC 62271-100. See Annex K.

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4 Normal and special service conditions

4.1 Normal service conditions

4.1.1 General

Subclause 4.1.1 of IEC 62271-1:2017 is applicable.

4.1.2 Indoor switchgear and controlgear

Subclause 4.1.2 of IEC 62271-1:2017 is applicable.

4.1.3 Outdoor switchgear and controlgear

Subclause 4.1.3 of IEC 62271-1:2017 is applicable with the following modifications and addition.

- a) The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C;
the ambient air temperature does not drop below -30 °C;

NOTE Rapid temperature changes can occur, for example a hot sunny day followed by a sudden rain.

- b) Solar radiation does not exceed a level of 1 044 W/m²;
- c) Ice coating does not exceed 1 mm.

Add the following specification:

For submersible units, the water head does not exceed 3 m above the base of the enclosure during occasional submersion. Exposure to chemical or electrochemical reactions may be encountered in a sub-grade environment. The sub-grade environment may contain chemicals that contribute to mild corrosive reactions.

4.2 Special service conditions

4.2.1 General

Subclause 4.2.1 of IEC 62271-1:2017 is applicable.

4.2.2 Altitude

Subclause 4.2.2 of IEC 62271-1:2017 does not apply and is replaced by the following.

The basis of rating for switchgear is standard reference atmosphere, commonly known as sea level conditions. Historically, switchgear has been successfully applied at altitudes up to 1 000 m without the use of an altitude correction factor.

For installations at an altitude higher than 1 000 m, the required insulation withstand level of external insulation at the service location shall be determined by multiplying the rated insulation levels at sea level by the altitude correction factor K_a in accordance with Figure J.1.

In this document, the rated symmetrical interrupting current (rated short-circuit breaking current), related required capabilities and interrupting times need not be corrected for altitude.

NOTE This document recognizes the revised IEEE treatment of altitude correction factors for applications above 1 000. Additional information is given in Annex J.

4.2.3 Exposure to pollution

Subclause 4.2.3 of IEC 62271-1:2017 is applicable.

4.2.4 Temperature and humidity

Subclause 4.2.4 of IEC 62271-1:2017 is not applicable.

For installation in a location where the ambient temperature can be outside the normal service condition range stated in 4.1.2 and 4.1.3, the usual ranges of minimum and maximum temperature to be specified should be:

- a) -50 °C to +40 °C for extremely cold climates;
- b) -40 °C to +40 °C for very cold climates;
- c) This range is not used, see note;
- d) -15 °C to +40 °C for moderate climates;
- e) -5 °C and +55 °C for very hot climates;
- f) -15 °C and +55 °C for hot and dry desert regions.

NOTE Range c) of IEC 62271-1, -30 °C to +40 °C, is not used in this document, because it is the same as the normal service conditions in 4.1.3.