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INTERNATIONAL STANDARD

IEEE Std C37.60™

NORME INTERNATIONALE

colour inside

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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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

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International Standard IEC 62271-111/IEEE Std C37.60 has been jointly revised by the Switchgear Committee of the IEEE Power and Energy Society, in cooperation with subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear, under the IEC/IEEE Dual Logo Agreement.

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.

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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
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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 (SF_6) 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.

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

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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

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

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[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.

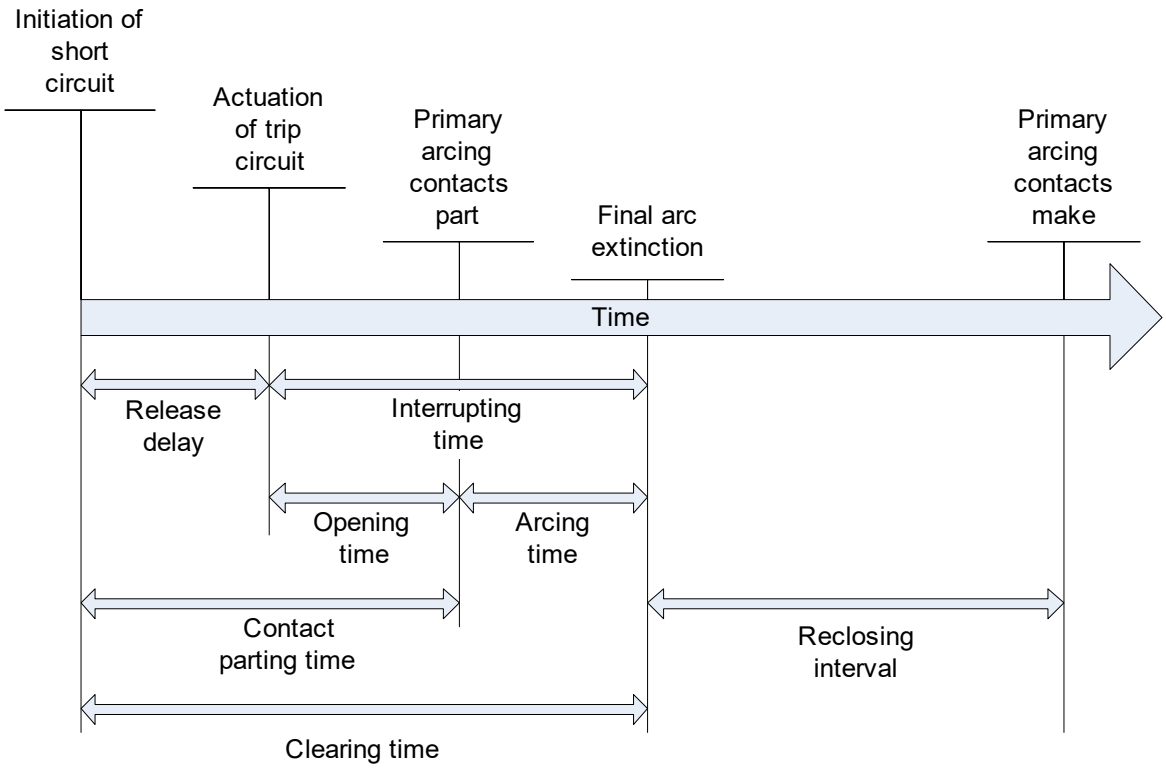

Figure 1 – Unit operation

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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

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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 IEV 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 IEV 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.

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b) Solar radiation does not exceed a level of 1 044 W/m^2;

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.

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4.2.5 Exposure to abnormal vibrations, shock or tilting

Subclause 4.2.5 of IEC 62271-1:2017 is applicable.

4.2.6 Wind speed

Subclause 4.2.6 of IEC 62271-1:2017 is applicable.

4.2.7 Other parameters

Subclause 4.2.7 of IEC 62271-1:2017 is applicable.

5 Ratings

5.1 General

Subclause 5.1 of IEC 62271-1:2017 is not applicable,

The ratings of the automatic circuit recloser and the cutout mounted recloser shall be as specified in Table 1.

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Table 1 – Ratings for automatic circuit reclosers and cutout mounted reclosers

Item	Rating description	Reference subclause	Automatic circuit recloser	Cutout mounted recloser
1	Rated maximum voltage (V) or (U_r)	5.2	X	X
2	Rated insulation level (U_d), (U_p)	5.3	X	X[b,c]
3	Rated frequency (f_r)	5.4	X	X
4	Rated continuous (normal) current (I_r)	5.5	X	X
5	Rated short-time withstand current (I_k)	5.6	X	X
6	Rated peak withstand current (I_p)	5.7	X	X
7	Rated duration of short circuit (t_k)	5.8	X	X
8	Rated supply voltage of closing and opening devices and of auxiliary circuits (U_a)	5.9	X	--
9	Rated minimum tripping current (series-trip reclosers only)	5.101	X	X
10	Rated short-circuit breaking current (I_{sc})	5.102	X	X
11	Rated symmetrical (fault) making current	5.103	X	X
12	Rated operating sequence	5.104	X	X
13	Rated line-charging (I_l) and cable-charging (I_C)current switching	5.106[a]	X	X[d]
14	First-pole-to-clear factor, k_{pp}	5.105		

[a] Line-charging, cable charging and load current switching are related required capabilities.

[b] Rated insulation levels for a cutout mounted recloser are derived in part from the fuse support or base in which it is installed. The fuse support or base shall be considered a part of the cutout mounted recloser for the purpose of type testing.

[c] Open position tests for cutout mounted reclosers are given for the device in the “dropped-out” position unless an operating sequence allows the device to rest with an open interrupter gap and a closed isolation gap in which case, both the isolation gap alone and the interrupter gap alone shall be tested for the open position test cases.

[d] Switching capability for a cutout mounted recloser may require the use of an auxiliary open and closing device. The auxiliary open and closing device shall be considered a part of the cutout mounted recloser for the purpose of type testing. Consult manufacturer for operating details.

5.2 Rated voltage (U_r)

Subclause 5.2 of IEC 62271-1:2017 is not applicable.

The rated voltage (rated maximum voltage) indicates the upper limit of the highest voltage of the system for which reclosers are intended to operate.

NOTE For purposes of this document, the term “rated voltage” (U_r) in IEC is equivalent to the term “rated maximum voltage” (V) in IEEE.

The values of rated voltage of reclosers are those shown in column 2 of Table 2 and Table 3.

5.3 Rated insulation level

Subclause 5.3 of IEC 62271-1:2017 is applicable, with the following modifications:

Table 1 and Table 2 of IEC 62271-1:2017 are replaced by Table 2 and Table 3 of this document.

NOTE Since the scope of this document is limited to a maximum rated voltage of 38 kV, Table 3 and Table 4 of IEC 62271-1:2017 do not apply.

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Table 2 – Rated maximum voltages and rated voltage withstand values for reclosers applied on overhead line distribution circuits[a]

Line No.	Rated maximum voltage	Rated lightning impulse withstand voltage [b]	Rated short-duration power-frequency withstand voltage
	kV, r.m.s.	kV, peak	kV, r.m.s.
Col. 1	Col. 2	Col. 3	Col. 4
1	12	75	28
2	15[c]	95	36
3	15,5	110	50
4	17,5	95	38
5	24	125	50
6	27	125	60
7	36	150	70
8	36	170	70
9	38	150	70
10	38	170	70

[a] The test values shown in Table 2 are for type tests; refer to 11.101 for field-testing.

[b] These performance characteristics specified as test requirements in this document.

[c] The 15 kV rating is used in North America 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.

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Table 3 – Rated maximum voltages and rated voltage withstand values for reclosers applied on cable connected distribution circuits [a]

Line No.	Rated maximum voltage	Rated lightning impulse withstand voltage	Rated short-duration power-frequency withstand voltage [b]	Related DC withstand test 15 min [b,c,d]
	kV, r.m.s.	kV, peak	kV, r.m.s.	kV
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
1	12	60	28	42
3	15,5	95	35	53
4	17,5	95	38	57
5	24	95	50	78
6	27	125	40	78
7	36	150	70	103
8	36	170	70	103
9	38	150	50	103
10	38	170	70	103

[a] The test values shown in Table 3 are for type tests; refer to 11.101 for field-testing.

[b] These are performance characteristics specified as test requirements in this document.

[c] DC withstand tests are required for pad-mounted, dry vault and submersible gear since this type of equipment is interfaced to the power system via separable connectors. The test requirements of separable connectors are specified IEEE Std 386 [6] and these values are reproduced here in column 5. The DC withstand test requirement on the recloser demonstrates its capability to withstand either DC withstand or the peak value of very low frequency (VLF) testing of connected cables.

[d] DC withstand testing of 36/38 kV cables is not a recommended practice. Very low frequency (VLF) testing is used as an alternative to the DC withstand test. Reference IEEE Std 400.2 [7].

5.4 Rated frequency (f_r)

Subclause 5.4 of IEC 62271-1:2017 is not applicable.

The rated power-frequency shall be the frequency at which the recloser and its components are designed to operate. The values of the rated power-frequency are 50 Hz or 60 Hz.

5.5 Rated continuous current (I_r)

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

The historic values of 560 A, 600 A, and 1 200 A, while not part of the R10 series, are also recognized as accepted commonly used values.

5.6 Rated short-time withstand current (I_k)

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

The historic values of 6 000 A and 12 000 A, while not part of the R10 series, are also recognized as accepted commonly used values.

NOTE The R10 series comprises the numbers 1 – 1,25 – 1,6 – 2 – 2,5 – 3,15 – 4 – 5 – 6,3 – 8 and their products by 10^n.

5.7 Rated peak withstand current (I_p)

Subclause 5.7 of IEC 62271-1:2017 is applicable.

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5.8 Rated duration of short-circuit (t_k)

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

The standard rated duration of short-circuit (t_k) is 0,5 s unless otherwise stated by the manufacturer and listed on the nameplate. Optional values are 1 s, 2 s and 3 s.

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

5.9.1 General

Subclause 5.9.1 of IEC 62271-1:2017 is applicable.

5.9.2 Rated supply voltage (U_a)

Subclause 5.9.2 of IEC 62271-1:2017 is not applicable.

The rated supply voltage should be selected from the standard values given in Table 4 and Table 5.

The values in Table 4 and Table 5 do not apply to line-powered or self-powered devices such as series trip or controls supplied by integrally mounted current transformers or internal batteries.

Refer to 6.4.1 and 6.9 for applicable voltage operating ranges.

Table 4 – Direct current voltage

U_a V
24
48
60 *
110 *
125
220 *
250
NOTE The values in this table are taken from IEC 62271-1. The values marked with an asterisk (*) are not common in IEEE standards.

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Table 5 – Alternating current voltages

Three-phase, three-wire or four-wire systems	Single-phase, three-wire systems	Single-phase, two-wire systems
(1)	(2)	(3)
--	120/240	120
120/208	--	120
230/400	--	230
277/480	--	277
347/600	--	347
NOTE The lower values in column (1) of this table are voltages to neutral and the higher values are voltages between phases. The lower value in column (2) is the voltage to neutral and the higher value is the voltage between lines.		

5.10 Rated supply frequency of auxiliary and control circuits

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

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.11 of IEC 62271-1:2017 is not applicable.

For devices that use a compressed gas supply, the rated pressure of compressed gas supply for insulation and/or operation shall be stated by the manufacturer.

5.101 Rated minimum tripping current ($I_{>min}$)

The minimum tripping current shall be stated by the manufacturer with a tolerance not to exceed the greater of ±10 % or ±3 A.

The minimum tripping current for shunt-trip reclosers is variable and is independent of the rated continuous (normal) current. Information on specific reclosers should be obtained from the manufacturer.

NOTE The term rated minimum tripping current ($I_{>min}$) is similar to the term G_T in IEC 60255-151 [8].

5.102 Rated short-circuit breaking current (I_{sc})

The rated short-circuit breaking current is the highest value of the symmetrical component of the short circuit current that the recloser shall be capable of breaking under the conditions of use and behaviour prescribed in this document. This implies that the circuit has a power-frequency recovery voltage corresponding to the rated voltage of the recloser and having a transient recovery voltage equal to the value specified in 7.103.6.

NOTE 1 The term rated symmetrical interrupting current as used in earlier editions of IEC 62271-111/IEEE Std C37.60 is replaced by the equivalent term short-circuit breaking current as used in IEC 62271-100.

The preferred rated short-circuit breaking current of reclosers shall be selected from the R10 series specified in IEC 60059 [9]. See Annex H for ratings for hydraulically controlled series-trip reclosers and oil interrupting reclosers.

NOTE 2 The R10 series comprises the numbers 1 – 1,25 – 1,6 – 2 – 2,5 – 3,15 – 4 – 5 – 6,3 – 8 and their products by 10^n.

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The rated short-circuit breaking current shall be based on the capability of the recloser to interrupt the corresponding asymmetrical current in circuits having X/R values as given in columns 5, 7, and 9 of Table 11 and with a power-frequency recovery voltage equal to the rated maximum voltage and with transient recovery voltages as defined in 7.103.6.

5.103 Rated short-circuit making current

Reclosers shall be capable of making, at any applied voltage up to and including that corresponding to their rated voltage, any current up to and including their rated short-circuit making current.

The rated short-circuit making current shall be the same value as the rated short-circuit breaking current, with maximum asymmetry corresponding to the X/R ratio in column 9 of Table 11. Refer to Annex A for information on calculating the peak current value.

5.104 Rated operating sequence

The rated characteristics of the recloser are referred to the rated operating sequence. The preferred rated operating sequence for automatic circuit reclosers shall be:

$$\text{O} - t - \text{CO} - t' - \text{CO} - t'' - \text{CO},$$

where

O represents an open operation;

CO represents a closing operation followed by an opening operation with a time delay controlled by the automatic control of the device.

Other sequences may be used.

The preferred values for the reclosing intervals are: t = 0,5 s, t' = 2 s and t'' = 5 s representing the fastest rapid reclosing interval capability of the device controlled by its automatic control. Other reclosing intervals may be used. See Annex H for rated operating sequence for oil interrupting reclosers.

The operating sequence and reclosing intervals represent the minimum required capability of the device and shall be demonstrated in the standard operating duty test specified in 7.103.4. Other operating sequences, delays and reclosing intervals may be available for selection by the user.

5.105 Rated first-pole-to-clear factor

The first-pole-to-clear factor (k_{pp}) is a function of the earthing of the system neutral. The rated values of k_{pp} are:

- 1,3 for systems with effectively earthed neutral;
- 1,5 for systems with non-effectively earthed neutral.

All reclosers shall be rated for a k_{pp} of 1,5; a rating for a k_{pp} of 1,3 is optional.

Single-phase reclosers that have completed the standard operating duty test at the required full U_r voltage are automatically qualified for both non-effectively earthed and effectively earthed neutral systems.

5.106 Rated line- (I_l) and cable-charging (I_c)interrupting currents

Line-charging current interruption tests are applicable to all reclosers for switching unloaded three-phase overhead lines. Cable-charging current interrupting tests are applicable to all

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reclosers for switching the charging current of unloaded lengths of cables. Line- and cable-charging current interruption are related required capabilities of all single- and three-phase reclosers. The tests are also applicable to the case of an overhead line in series with short lengths of cable.

Single-phase reclosers are frequently applied in a set of three on a three-phase circuit. Accordingly, single-phase reclosers are required to meet the line- and cable-charging current tests.

NOTE No capacitive current switching class similar to IEEE C37.09a and IEC 62271-100 is assigned to reclosers.

Cables are considered to be short if the total charging current does not exceed 20 % of the overhead line-charging current and the charging current of any cable adjacent to the recloser does not exceed 10 % of the overhead line-charging current. In any case, the total current shall not exceed the rated line-charging interrupting current.

The preferred line- and cable-charging interrupting current ratings for reclosers are as given in Table 6.

Table 6 – Preferred line- and cable-charging interrupting current ratings

Rated maximum voltage kV	Rated breaking current A (r.m.s.)	
	Line charging	Cable charging
12	2	10
15 and 15,5	2	10
17,5	2	10
24	5	25
27	5	25
36	5	40
38	5	40

6 Design and construction

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC 62271-1:2017 is applicable with the following addition.

Oil sampling provision (submersible reclosers): when oil is used as the insulating medium, provision shall be made to obtain a bottom oil sample.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC 62271-1:2017 is applicable.

6.3 Earthing of switchgear and controlgear

NOTE The terms “ground” and “grounding” in IEEE are equivalent to the IEC terms “earth” and “earthing”.

Subclause 6.3 of IEC 62271-1:2017 is not applicable.

Reclosers shall be provided with a reliable earthing point for connection of an equipment earth conductor (EGC) suitable for the specified fault conditions. Parts of metallic enclosures connected to the earthing system may be designed to be part of the earth circuit.

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All conductive components and enclosures that may be touched during normal operating conditions and are intended to be grounded shall be designed to carry 30 A (DC) with a voltage drop of maximum 3 V to the grounding point provided at the recloser. For purposes of this subsclause, the term “conductive” does not include semi-conductive surfaces.

A recloser control housing that may be mounted separately from the recloser or that contains control elements that rely on solid earthing (grounding) for surge immunity shall also have provisions for the connection of an earth (ground) lead.

Pad mounted, dry vault and submersible reclosers shall have an additional earthing (grounding) connection for each three-phase set of cable entrances.

6.4 Auxiliary and control equipment

6.4.1 General

Subclause 6.4.1 of IEC 62271-1:2017 is not applicable.

Switchgear, including all auxiliary circuits (electronic controls, supervision, monitoring and communication), that relies solely on an auxiliary power supply shall be able to operate normally when the auxiliary power supply measured at the supply terminals of the auxiliary equipment is such that:

- the voltage variation is within the limits of the supply voltages shown in Tables 4 and 5;
- in the case of a DC auxiliary supply voltage, the ripple voltage is limited to a value not greater than 5 % of the DC component.

The requirements for voltage variation do not apply to self-powered control equipment, e.g. powered by integrally mounted current transformers or battery powered controls.

6.4.2 Protection against electric shock

Subclause 6.4.2 of IEC 62271-1:2017 is applicable with the following modification.

Special access restrictions may be required for overhead/pole mounted reclosers. See 6.4.3.

6.4.3 Components installed in enclosures

6.4.3.1 General

Subclause 6.4.3 of IEC 62271-1:2017 is not applicable.

6.4.3.2 Accessibility

Closing and opening actuators and emergency shut-down system actuators shall be located between 0,4 m and 2 m above the floor, ground or operating platform normally used by operating personnel. This requirement does not apply to separately mounted control enclosures where they may need to be elevated to prevent access by the general public according to local requirements and work practices.

Other actuators should be located at such a height that they can be easily operated, and indicating devices should be located at such a height as to be readily legible.

6.4.3.3 Identification

Identification of components installed in enclosures shall be in agreement with the indication on the wiring diagrams and drawings.

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6.4.3.4 Auxiliary switches

Auxiliary switches shall be suitable for the number of electrical and mechanical operating cycles specified for the switching device.

6.4.3.5 Auxiliary and control contacts

Auxiliary and control contacts shall be suitable for the number of electrical and mechanical operating cycles specified for the switching device. This requirement shall be verified by the mechanical endurance test of the switching devices.

6.4.3.6 Heating elements

All heating elements shall be of the non-exposed type.

Where contact with a heater or shield can occur accidentally, the surface temperature shall not exceed the temperature limits for accessible parts not to be touched in normal operation, as specified in 7.5.6.

6.4.3.7 Operation counter

Operation counter shall be suitable for its intended duty in terms of environmental conditions and for the number of electrical and mechanical operating cycles specified for the switching device.

6.5 Dependent power operation

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

6.6 Stored energy operation

6.6.1 General

Subclause 6.6 of IEC 62271-1:2017 is not applicable.

A switching device arranged for stored energy operation shall be capable of making and breaking all currents up to its rated values when the energy storage device is suitably charged. Except for slow operation during maintenance, the main contacts shall only move under the action of the drive mechanism and in the designed manner, and not in the case of re-application of the energy supply to the energy storage device after a loss of energy.

A device indicating when the energy storage device is charged shall be mounted on the switching device except in the case of an independent unlatched operation, see 6.7.

It shall not be possible for the moving contacts to move from one position to the other, unless the stored energy is sufficient for satisfactory completion of the opening or closing operation. Stored energy systems for both opening and closing shall be capable of being discharged, restrained or otherwise reduced to a condition consistent with personnel safety during maintenance operations by properly trained personnel.

When indicators are used on stored energy operating mechanisms, the following colours are suggested subject to any local codes:

a) yellow background with CHARGED in black letters for charged mechanisms;

b) white background with DISCHARGED in black letters for discharged mechanisms.

As an alternative, red letters on a white background for both indicators may be used.

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The words “CHARGED” and “DISCHARGED” are given in the English language as an example. The actual language used shall be as specified or as is customary for the intended user.

NOTE Further guidance on the colours or symbols may be found in IEC 60073 [10] and IEC 60417 [11].

Customer (user) preferences or local codes for indicators should be specified by the user.

6.6.2 Energy storage in gas receivers or hydraulic accumulators

When the energy storage device is a gas receiver or hydraulic accumulator, the requirements of 6.6.1 apply at operating pressures between the limits specified in items a) and b).

a) External pneumatic or hydraulic supply

   Unless otherwise specified by the manufacturer, the limits of the operating pressure are 85 % and 110 % of their specified rated pressure.

   Higher limits may apply where receivers also store compressed gas for interruption. The applicable equipment standard should address as needed the maximum limit if applicable.

b) Compressor or pump integral with the switching device or the operating device

   The limits of operating pressure shall be stated by the manufacturer.

6.6.3 Energy stored in springs (or weights)

When the energy storage device is a spring (or weight), the requirements of 6.6.1 apply when the spring is charged (or the weight lifted).

6.6.4 Manual charging

If a spring (or weight) is charged by hand, the direction of motion of the handle shall be marked.

The manual charging facility shall be designed such that the handle is not driven by the operation of the switching device.

The maximum actuating force required for manually charging a spring (or weight) shall not exceed 250 N (56 lb_f (pound-force)).

6.6.5 Motor charging

Motors, and their electrically operated auxiliary equipment for charging a spring (or weight) or for driving a compressor or pump, shall operate satisfactorily within the limits of the voltages in 5.9, the frequency, in the case of AC, being the rated supply frequency.

NOTE For electric motors, the limits do not imply the use of non-standard motors but only the selection of a motor which at these values provides the necessary effort, and the rated voltage of the motor need not coincide with the rated supply voltage of the closing device.

6.6.6 Energy storage in capacitors

When the energy storage is a charged capacitor, the requirements of 6.6.1 apply when the capacitor is charged except that indication of the charged state may be placed on the energy storage device rather than the switching device. In the case of an energy storage device embedded within electronic controls of the recloser, a ‘readiness to operate’ indicator satisfies this requirement.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC 62271-1:2017 is applicable with the following addition.

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Reclosers shall be provided with a manual operating lever to open the recloser. The operating lever shall be suitable for operation with a hot line stick or insulating stick.

Some applications may require that the operating lever on a submersible recloser be located such that one person standing on the surface can operate it without standing directly over the recloser. These special applications should be specified by the user.

6.8 Manually operated actuators

Subclause 5.8 of IEC 62271-1:2017 is applicable.

6.9 Operation of releases

6.9.1 General

Subclause 6.9.1 of IEC 62271-1:2017 is applicable.

6.9.2 Shunt closing release

Subclause 6.9.2 of IEC 62271-1:2017 is applicable.

6.9.3 Shunt opening release

Subclause 6.9.3 of IEC 62271-1:2017 is applicable.

6.9.4 Capacitor operation of shunt releases

Subclause 6.9.4 of IEC 62271-1:2017 is applicable

6.9.5 Under-voltage release

Subclause 6.9.5 of IEC 62271-1:2017 is applicable.

6.10 Pressure/level indication

Subclause 6.10 of IEC 62271-1:2017 is applicable.

6.11 Nameplates

Subclause 6.11 of IEC 62271-1:2017 is applicable, with the following additions.

The nameplates for recloser shall be marked in accordance with Table 7.

If the recloser consists of several poles with independent operating mechanisms, each pole shall be provided with a nameplate. This requirement does not apply if all of the pole mechanisms are mounted to a common structure.

If the recloser is operated or controlled by a detachable control enclosure, this enclosure shall also have an appropriate nameplate.

For submersible reclosers, a nameplate of stainless steel or other corrosion resistant material shall be provided. The nameplate shall be securely attached to the top of the tank by means of stainless steel screws, rivets, or other corrosion resistant fasteners. All letters, schematics and numbers shall be permanently stamped, embossed or engraved on the nameplate.

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Table 7 – Nameplate markings

Term	Abbreviation[a]	Unit	Condition: Marking only required if	Marking requirement[b]
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Manufacturer's name or trademark				X
Manufacturer's type designation				X
Equipment type		[c]		X
Rated maximum voltage	V or U_r	kV		X
Rated power-frequency withstand voltage	U_d	kV		X
Rated lightning impulse withstand voltage	U_p	kV		X
Rated power-frequency	f_r	Hz	Rating is not applicable at both 50 Hz and 60 Hz	Y
Rated continuous (normal) current	I_r	A		X
Rated duration of short circuit	t_k	s	Different from 0,5 s	Y
Rated short-circuit breaking current	I_{sc}	A or kA		X
First pole-to-clear factor	k_{pp}		Specify 1,3 if rated for both 1,5 and 1,3	Y
Rated minimum tripping current	$I_{>min}$	A	Non-adjustable series-trip reclosers	Y
Ice breaking capability		mm	Greater than 1 mm thickness and if type testing is required, see 6.110	Y
Type and quantity (volume of liquid or mass of gas) of insulating material		l or kg [d]	Contains liquid or gas	Y
Mass (including oil for oil-filled devices)		kg (lbs) [d]		X
Serial number and date of manufacture				X

A separate auxiliary nameplate or label may be used for supply voltage information.

[a] The abbreviation in column 2 may be used instead of the term in column 1. When the term in column 1 is used, the word "rated" is not required.

[b] X = the marking of these values is mandatory; blanks indicate the value zero.

Y = the marking of these values to the conditions in column 4.

[c] Equipment type: the nameplate shall also contain the word(s) "recloser"or "cutout mounted recloser" in accordance with its operating sequence capability as given in 5.104.

[d] SI metric units are preferred; however country specific units may be used, e.g. US gallons (US gal,) pound-force (lb_f), pound mass (lb_m).

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6.12 Locking devices

Subclause 6.12 of IEC 62271-1:2017 is applicable.

6.13 Position indication

Subclause 6.13 of IEC 62271-1:2017 is applicable with the following additions:

For pad mounted, dry vault or submersible reclosers viewing of the position indicator may require opening of the pad-mounted or underground enclosure.

In the absence of user specifications, the preferred colours to indicate an open or closed position are red to signify closed and green to signify open.

6.14 Degrees of protection provided by enclosures

6.14.1 General

Subclause 6.14 of IEC 62271-1:2017 is not applicable. The degrees of protection provided by enclosures shall be in accordance with IEC 60529 and 6.14.2 through 6.14.4.

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

6.14.2.1 General requirements

The degree of protection of persons and of equipment provided by an enclosure against access to hazardous parts of the main circuit, control and/or auxiliary circuits and to any hazardous moving parts and against ingress of solid foreign objects shall be at least IP1XB according to IEC 60529.

6.14.2.2 Requirements for equipment in publicly accessible areas

Equipment including control enclosures that are intended for installation in publicly accessible areas shall conform to the degree of protection level IP4X or higher. Such enclosures shall be designed to mitigate the potential hazards of the equipment to unauthorized persons. Consideration for securing associated external cable and cable connections and the prevention of internal access other than by authorized personnel shall be agreed upon between the user and the manufacturer.

In order to secure the control enclosure, the following measures are typically used to address the hazards presented by publicly accessible equipment.

a) Three-point door latching mechanisms, or equivalent, are used to secure a door of entry.

NOTE 1 A three-point latching mechanism allows for all un-hinged sides of a door to be latched, thereby securing all sides of a door. Such mechanism greatly increases the security of the door compared to a single-point latching mechanism.

b) Enclosure panels are fastened or hinged to resist disassembly, breaking, or prying open from the outside with the doors in the closed and locked position. No externally removable screws, bolts, or other fastening devices exist by which access to energized parts in the enclosure might be obtained without the use of special tools.

c) Locking bolts and associated threaded receptacles, hinges, and hinge pins are AISI6 type 304 stainless steel or material of equivalent corrosion resistance.

d) Enclosures have padlock provisions, utilizing a minimum of one padlocking means provided per entry door.

NOTE 2 In some jurisdictions and when specified by the user, conformance to IEEE Std C57.12.28.xx may be required.

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6.14.3 Protection against ingress of water (IP coding)

Reclosers shall conform to the degree of protection level IPX3 or higher according to IEC 60529.

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

Subclause 6.14.4 of IEC 62271-1:2017 is not applicable.

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC 62271-1:2017 is applicable.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is applicable.

6.17 Tightness for liquid systems

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

Tank construction for liquid filled or non-pressurized devices shall be such that leaks will not occur and the recloser will remain mechanically operable at the maximum pressure generated by the normal operation of the recloser (for example, temperature rise, load interrupting and fault closing).

6.18 Fire hazard (flammability)

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

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC 62271-1:2017 is not applicable.

The control elements supplied with shunt-trip reclosers shall withstand, without damage, voltage surges originating in the low-voltage energy source, in either or both of the current and voltage transformers connected to the control elements, or in the control leads connecting the recloser and the control elements. The tests specified in 7.111 demonstrate this capability.

6.20 X-ray emission

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

6.21 Corrosion

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

6.22 Filling levels for insulation, switching and/or operation

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

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6.101 Tank construction: submersible or dry vault reclosers

6.101.1 Tank material and finish

The tank and all attachments shall be made of corrosion resistant material or provided with an impact and corrosion resistant finish and shall also be suitable for storage in uncovered areas.

6.101.2 Water entrapment

External parts of the tank or accessories shall not trap or hold water.

6.101.3 Tank support

Tank support shall include provision for anchoring the tank.

6.101.4 Lifting lugs

Attachment points for lifting the recloser shall be provided to permit lifting and installation in accordance with the manufacturer's instructions. They shall be designed and located on the tank to avoid interference between lifting slings and any attachments (bushings, operating handles, etc.), and to avoid scratching or marring the tank finish during handling.

6.102 Counters

An operations counter shall be provided to indicate the total number of unit operations of automatic reclosers. The counter shall be visible with the recloser in service.

6.103 Conductor terminal sizes

For connection of bare conductors, terminals shall accommodate conductors of a size adequate to conduct the rated continuous (normal) current of the recloser without exceeding the appropriate temperature rise shown in 7.5.5.

For reclosers fitted with cable terminations, bushings should accommodate cable terminations in accordance with IEEE Std 386 [6] or the IEC 60502 series [12] unless otherwise specified by the user.

7 Type tests

7.1 General

7.1.1 Overview

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

Reclosers shall be capable of meeting the type tests described in 7.2 through 7.11 inclusive and 7.101 through 7.113 inclusive and as applicable. Once made, the type tests need not be repeated unless the design is changed so as to modify the performance characteristics of the recloser.

Reconditioning is not permitted during any individual type test. The complete standard operating duty test specified in 7.103 is considered as one type test.

Refer to Annex E for tolerances applied to test values.

NOTE The term "type test" in IEC is equivalent to the IEEE term "design test".

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7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC 62271-1:2017 is applicable with the following addition:

The definition of an automatic circuit recloser includes its automatic control. Manufacturer shall include in the information provided to the testing laboratory sufficient information to identify the control used in the type tests. Where appropriate, this information shall include model number, serial number, firmware revision, software revision and other appropriate control software information.

The definition of a cutout mounted recloser includes a fuse type mounting or support. This mounting or support is integral to the dielectric capability of the device. The manufacturer shall include in the information provided to the testing laboratory sufficient information to identify the mounting or support used in the type tests. Where appropriate, this information shall include make, model number and rating.

7.1.3 Information to be included in type-test reports

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

The definition of an automatic circuit recloser includes its automatic control. The control shall be considered an essential part of the switchgear in the test report including its model number, serial number, firmware revision, software revision and other appropriate control schemes.

The definition of a cutout mounted recloser includes a fuse type mounting or support. This mounting or support shall be considered an essential part of the switchgear and noted in the test report including its make, model number and rating.

A cutout mounted recloser may require the temporary attachment of an auxiliary device to perform the related switching functions of a recloser. If such a device is required, it shall be considered an essential part of the switchgear and noted in the test report including its make, model number and rating.

The test arrangement including mounting and use of auxiliary devices shall be noted in the test report.

NOTE An auxiliary device may be a separable attachment that is used to perform non-automatic switching functions and is then removed for normal automatic operation. Such a device may perform a quick-break or arc snubbing action to extinquish the arc when the cutout mounted recloser is opened manually.

In this document, the term “control voltage” has the same meaning as “auxiliary supply voltage”.

7.1.101 Test conditions

7.1.101.1 Condition of device to be tested

The recloser shall be new and in good condition.

7.1.101.2 Mounting of device

The recloser shall be mounted in a manner closely approximating the normal service conditions for which it is designed. If the recloser normally requires control apparatus, the control apparatus shall be connected during the tests observing the following minimum requirements:

a) the control shall be mounted on the recloser as intended by the manufacturer’s design or positioned within 2 m of the recloser phase terminals under test;

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b) the recloser shall be connected to the control apparatus with the manufacturer's approved cable whose length shall be the maximum allowed by the manufacturer except that it need not exceed 6 m;

c) the control shall be placed in the same room as the recloser without any additional shielding except that which is provided by the manufacturer for normal service;

d) the connections to the terminals of the switchgear shall be arranged in such a way as to avoid unrealistic stressing of the terminals. The distance between the terminals and the nearest supports of the conductors on both sides of the switchgear shall be in accordance with the instructions of the manufacturer;

e) a cutout mounted recloser may require the temporary attachment of an auxiliary device to perform the related switching functions of a recloser. If such a device is required, it need not be mounted except for those tests requiring its use, see Note in 6.1.3.

If the control apparatus is intended by the manufacturer to always be integrally mounted to or within the recloser structure, it shall be considered in compliance with a) and b) above with a zero length control cable.

7.1.101.3 Earthing (grounding) of device

All parts of the recloser, including control apparatus where used, shall be earthed by a lead attached to the earth terminal and other parts to be earthed, in a manner not to decrease the withstand voltage.

7.1.101.4 Power frequency

Reclosers shall be tested at rated frequency with a tolerance of ±5 %. However, for convenience of testing, some deviations from the above tolerance are allowable; for example, when reclosers rated at 50 Hz are tested at 60 Hz and vice versa, care should be exercised in the interpretation of the results, taking into account all significant facts such as the type of the recloser and the type of test performed.

NOTE 1 In particular, it is recognized that for most vacuum interrupters, di/dt is not a relevant criterion for comparison and tests at 50 Hz are acceptable for 60 Hz ratings, but not vice versa.

NOTE 2 Refer to IEC TR 62271-306 [13] for additional information about the applicability of tests at different frequencies.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2.1 of IEC 62271-1:2017 is applicable with the following additions and modifications:

Rated insulation levels for cutout mounted reclosers are based in part on the rating of the fuse support or base identified by the manufacturer in 7.1.1 and 7.1.2. See 7.2.6.3 for special test conditions for the cutout mounted recloser.

Reclosers shall be capable of withstanding, without damage to either the recloser or its associated control apparatus, if any, the test voltages of Table 2 or Table 3, when tested in accordance with 7.1.

7.2.2 Ambient air conditions during tests

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

7.2.3 Wet test procedure

Subclause 7.2.3 of IEC 62271-1:2017 is applicable.

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7.2.4 Arrangement of the equipment

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

a) On overhead reclosers electrical connections shall be made by means of bare wire, connected in each terminal. These bare wires shall project in such a manner as not to decrease the withstand value. Any necessary bends may be made at the terminals. The test lead connections shall be made to the wires projecting from the terminals. Terminals shall be representative of those used in service;

b) On pad mounted, submersible and dry vault reclosers, connections shall be made through a cable termination similar to that for which the recloser was designed. If terminations capable of meeting the specified dielectric voltage are not available, other terminations (bushing or connectors, or both) may be substituted for the purpose of performing these tests.

7.2.5 Criteria to pass the test

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

When testing switchgear incorporating an open vacuum interrupter, for each polarity, a maximum of 25 preliminary impulse tests may be performed at up to and including the rated withstand voltage. The number and level of preliminary impulses is to be stated by the manufacturer. Breakdowns that are observed during these preliminary tests shall be disregarded for the purposes of the withstand statistics used to determine pass or fail performance of the equipment.

NOTE For more information about the application of preliminary impulses to an open vacuum interrupter, see reference [14].

7.2.6 Application of the test voltage and test conditions

7.2.6.1 General

Subclause 7.2.6.1 of IEC 62271-1:2017 is applicable.

7.2.6.2 General case

Subclause 7.2.6.2 of IEC 62271-1:2017 is applicable with the following addition:

Single-phase reclosers shall be tested for conditions 1, 4 and 7 of Table 10 of IEC 62271-1:2017. The connections of the terminals for phases B and C are not applicable.

7.2.6.3 Special case

Subclause 7.2.6.3 of IEC 62271-1:2017 is applicable with the following addition:

The open position tests for cutout mounted reclosers are given for the device in the “dropped-out” position.

If the operating sequence allows the device to rest with an open interrupter gap and a closed disconnector gap, both the isolation gap alone and the interrupter gap alone shall be tested for the open position test cases, e.g. cutout mounted reclosers.

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

7.2.7.1 General

Subclause 7.2.7.1 of IEC 62271-1:2017 is applicable with the following modifications:

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The tests shall be performed with the test voltages equal to the withstand values of Table 2 or Table 3.

NOTE The scope of this document is limited to the voltage range above 1 000 V up to and including 38 000 V.

7.2.7.2 Power-frequency voltage tests

Subclause 7.2.7.2 of IEC 62271-1:2017 is applicable.

7.2.7.3 Lightning impulse voltage tests

Subclause 7.2.7.3 of IEC 62271-1:2017 is applicable with the following addition.

The average value of all tests in a group shall equal or exceed the rated value.

7.2.7.101 DC withstand test voltage

On reclosers using pad mounted, dry vault, and submersible cable connectors, a DC withstand test shall be performed in addition to the power-frequency withstand test in 7.2.7.1 above. When used, the test voltage applied shall be the value given in column 5 of Table 3. DC or very low frequency test voltages are used on cables that still may be connected to the switchgear. This type test is included to verify that the switchgear can also withstand the same test voltage.

Refer to 11.101 for a discussion on field tests.

The DC power source for the DC withstand test shall be capable of supplying a minimum of 10 mA before tripping out on overload. The test shall be considered to have failed if there is:

a) a leakage current of more than 10 mA, or

b) the test device is unable to withstand the voltage.

Non-sustained disruptive discharges may occur and are allowed.

NOTE These test criteria recognize the likelihood that a small leakage current may pass through an insulating medium or across an insulating surface while still supporting the high DC voltage. This is particularly true of vacuum interrupters.

7.2.8 Test of switchgear and controlgear of U_r > 245 kV

Subclause 7.2.8 of IEC 62271-1:2017 is not applicable, since the scope of this document is limited to 38 kV and below.

7.2.9 Artificial pollution tests for outdoor insulators

Subclause 7.2.9 of IEC 62271-1:2017 is applicable.

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2017 is not applicable; RIV tests are not a requirement of this document.

7.4 Resistance measurement

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

Subclause 7.4.1 of IEC 62271-1:2017 is not applicable.

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7.4.2 Measurement of the resistance of auxiliary contacts class 3

Subclause 7.4.2 of IEC 62271-1:2017 is not applicable.

7.4.3 Electrical continuity of earthed metallic parts test

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

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

Subclause 7.4.4 of IEC 62271-1:2017 is applicable.

7.5 Continuous current tests

7.5.1 Condition of the test object

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

7.5.2 Arrangement of the equipment

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

The test object shall be arranged in accordance with 7.1.

7.5.3 Test current and duration

7.5.3.1 Test on main circuit

Subclause 7.5.3.1 of IEC 62271-1:2017 is applicable.

7.5.3.2 Test of the auxiliary and control equipment

Subclause 7.5.3.2 of IEC 62271-1:2017 is not applicable.

The continuous current or temperature rise test requirement for other auxiliary and control equipment is addressed by the successful completion of the interrupting duty, mechanical endurance test and temperature rise of the main circuit.

Since the auxiliary and control equipment is included in the definition of an automatic circuit recloser, it is required that this auxiliary and control equipment be included in the operation of the recloser during the interrupting duty and mechanical endurance tests.

7.5.4 Temperature measurement during test

7.5.4.1 Ambient air temperature

Subclause 7.5.4.1 of IEC 62271-1:2017 is applicable with the following additions.

The method of measuring the ambient air temperature specified in IEC 62271-1:2017 is the preferred method.

Methods for the measurement of ambient temperature described in previous editions of IEC 62271-111 are also considered valid.

7.5.4.2 Temperature of test object

Subclause 7.5.4.2 of IEC 62271-1:2017 is applicable with the following addition.

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The following arrangement shall be allowed as an alternate to the arrangement of equipment specified in subclause 7.5.4.2 of IEC 62271-1:2017, in which case the 5 K difference of temperature rise between the terminals and the external connections shall not apply.

The recloser shall have a conductor connected to each terminal having a minimum length of 1,2 m. For reclosers with bushings designed for connection to bare copper conductors, use cables no larger than listed in Table 8. For aluminium cables use Table 9. For reclosers designed for use with submersible or insulated cables, the cables shall be chosen for the rated current and voltage of the recloser. Refer to IEEE Std 386 for guidance. The connection shall be made to the ends of these conductors.

For rated continuous current levels greater than those in Table 8 or Table 9, the arrangement given in IEC 62271-1:2017 shall be followed.

Table 8 – Size of bare copper leads [a]

Rated continuous (normal) current A	Size of leads		
	AWG	kcmil	mm^2
Up to 50	#6 solid	26,2	13
70 to 100	#2/0 stranded	133	67
140 to 200	#4/0 stranded	211	107
250 to 315	–	400	200
400	–	500	250
500	–	600	300
630	–	750	400
800	–	1 000	500
[a] Multiple (parallel) conductors of equivalent net cross-section are permitted.			

Table 9 – Size of bare aluminium leads [a]

Rated continuous (normal) current A	Size of leads		
	AWG	kcmil	mm^2
200	#4/0 stranded	211	107
500	–	1 000	500
630	–	1 250	625
[a] Multiple (parallel) conductors of equivalent net cross-section are permitted.			

7.5.5 Resistance of the main circuit

Subclause 7.5.5 of IEC 62271-1:2017 is applicable.

7.5.6 Criteria to pass test

Subclause 7.5.6 of IEC 62271-1:2017 is applicable.

7.6 Short-time withstand current and peak withstand current tests

Subclause 7.6 of IEC 62271-1:2017 is applicable with the following additions.

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The peak current (for a three-phase circuit, the highest value in one of the outer phases) shall be not less than the rated peak withstand current (I_p) and shall not exceed it by more than 5 % without the consent of the manufacturer.

7.7 Verification of the protection

Subclause 7.7.1 of IEC 62271-1:2017 is applicable with the limitations and exceptions given in 6.14.

Subclause 7.7.2 of IEC 62271-1:2017 is not applicable.

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2017 is applicable.

7.9 Electromagnetic compatibility tests (EMC)

Subclause 7.9 of IEC 62271-1:2017 is not applicable.

See 7.111 for tests on the electronic control elements of a recloser.

7.10 Additional tests on auxiliary and control circuits

Subclause 7.10 of IEC 62271-1:2017 is not applicable.

The successful completion of the interrupting duty, mechanical endurance test, and continuous current test of the main circuit is considered adequate verification of the auxitiary and control circuits.

NOTE Since the auxiliary and control equipment is included in the definition of an automatic circuit recloser, this auxiliary and control equipment is included in the operation of the recloser during the interrupting duty and mechanical endurance tests.

7.11 X-radiation test procedure for vacuum interrupters

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

7.101 Line-charging current and cable-charging current interruption tests

7.101.1 General

In laboratory tests the lines and cables may be partly or fully replaced by artificial circuits with lumped elements of capacitors, reactors or resistors. Phenomena occurring after a restrike or a re-ignition event are not representative of service conditions as the test circuit does not adequately reproduce the post-event voltage conditions.

Single-phase reclosers are frequently applied in a set of three on a three-phase circuit. Accordingly, single-phase reclosers are required to meet the line- and cable-charging current tests.

7.101.2 Characteristics of supply circuits

The supply circuit frequency shall be the rated frequency with a tolerance of ±2 %.

Tests at 60 Hz demonstrate the breaking characteristics at 50 Hz.

Tests at 50 Hz may be considered to prove the characteristics at 60 Hz, provided that the voltage across the recloser is not less during the first 8,3 ms than it would be during a test at

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60 Hz with the specified voltage. This implies that the peak of a 50 Hz source voltage will be greater than a test at 60 Hz. If a restrike occurs after 8,3 ms, due to the instantaneous voltage being higher than it would be during a test at 60 Hz, then the test-duty should be repeated at 60 Hz.

The test circuit shall fulfil the following requirements:

a) the source impedance Z_s shall be in the range of a T20 circuit and a T50 circuit;

b) the power factor of the source impedance shall be between 5 % and 20 %.

The prospective transient recovery voltage of the supply circuit shall be no more severe than the transient recovery voltage specified for short-circuit test duty T50. Inrush currents may be controlled using a damping circuit.

7.101.3 Earthing (grounding) of the supply circuit

The source neutral for the three phase circuit shall be solidly earthed (grounded). For singe-phase tests, the circuit shall be earthed (grounded) but the grounding may be at either terminal of the supply circuit. Figures 2a and 2b show the test circuit diagrams.

7.101.4 Characteristics of the capacitive circuit to be switched

7.101.4.1 General

The characteristics of the capacitive circuit shall, with all necessary measuring devices such as voltage dividers included, be such that the decay of the voltage at load side does not exceed 10 % at the end of an interval of 300 ms after final arc extinction.

When capacitors are used to simulate cables or lines, a resistor (R_{surge}) of a maximum value of 5 % of the capacitive impedance may be inserted in series with the capacitors. Higher values are not permitted as they may unduly influence the recovery voltage.

See Figure 2 for test circuit where C_1 is selected to yield the test current; C_0 is determined by C_1/C_0 ratio given in Table 10. For shielded cables, C_1 = C_0 and the wye-connected capacitors are not used.

7.101.4.2 Three-phase reclosers with independent pole tripping

Three-phase reclosers that are capable of independent pole tripping, i.e. the poles are not ganged together, may be tested by either one of the following methods. In both cases, tests on only one of the phases is required:

a) single-phase tests on one of the phases using a single-phase circuit with a test voltage in accordance with 7.101.6;

b) single-phase tests in a three-phase test circuit with two phases of the capacitive circuit connected directly to the three-phase supply circuit and one phase connected to the supply circuit through the circuit-breaker pole to be tested.

7.101.4.3 Line-charging current switching tests

Where it is permissible to use parallel lines or to partly or fully replace the real three-phase line with concentrated capacitor banks, the resulting positive sequence capacitance shall be approximately three times the zero sequence capacitance.

7.101.4.4 Cable-charging current switching tests

Capacitors may be used to simulate cables. For three-phase tests representing three-core belted cables, the positive sequence capacitance shall be approximately two times the zero sequence capacitance.

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NOTE The objective is to base the test on test parameters i.e. C_1/C_0 ratio, rather than cable types. The value of 2,0 for this ratio is considered to be the more severe case for three-core belted and shielded cable types.

A short overhead line may be used in series with a cable for the tests, provided the line-charging current does not exceed 1 % of the cable-charging current.

7.101.5 Waveform of the current

The waveform of the current to be interrupted should be sinusoidal. This condition is considered to be satisfied if the ratio of the r.m.s. value of the current to the r.m.s. value of the fundamental component does not exceed 1,2.

The current to be interrupted shall not go through zero more than once per half-cycle of power frequency.

7.101.6 Test voltage

Single-phase testing is not permitted for verification of three-phase switching performance except as provided in 7.101.4.2.

The power-frequency test voltage is the average of the phase-to-phase voltages, and shall be measured in the interval between 1 cycle and 1,5 cycles after the final phase arc-extinction. An acceptable alternate is the average of the phase-to-ground voltages multiplied by $\sqrt{3}$.

The test voltage in the case of three-phase tests on three-phase reclosers or on single-phase reclosers shall be equal to or greater than the rated maximum voltage of the recloser. The three individual phase voltages shall not vary more than 10 % of the average value.

The power frequency test voltage and the DC voltage resulting from the trapped charge on the capacitive circuit shall be maintained for a period of at least 0,3 s after breaking.

The voltage magnitude after clearing can escalate with multiple restrikes and test laboratories may shut power off to protect their equipment. The recloser shall withstand the recovery voltage for a minimum of 0,3 s after breaking for the operation to be considered successful. Otherwise, the operation shall not be counted as either a successful or an unsuccessful operation.

NOTE This document is limited in scope to rated maximum voltages of 38 kV and below. Most test laboratories can handle the switching test requirements of this document without having to resort to single-phase testing for verification of three-phase performance.

7.101.7 Test current

The tests shall be performed at the rated capacitive currents stated by the manufacturer. The minimum required current ratings are specified in Table 6.

7.101.8 Test-duties

The two test-duties shall be performed on one test object without any maintenance. The following abbreviations apply:

- line-charging current, test duty LC;
- cable-charging current, test duty CC.

Capacitive current switching tests for reclosers shall be made after performing at least one rated operating sequence of test-duty T20 as a preconditioning test (T20 is related to the rated breaking capability of the recloser).

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As an alternative, the preconditioning test may consist of the following:

- same current as test-duty T20;
- no specified transient recovery voltage;
- at least four opening operations.

NOTE 1 The manufacturer may choose to perform additional iterations of the T20 preconditioning tests.

NOTE 2 Arcing times for preconditioning tests at T20 are not specified.

The capacitive current switching tests shall consist of the test-duties as specified in Table 10.

Table 10 – Switching test duties

Test type	Number of operations	C_1/C_0	Test current
Preconditioning [a]	Minimum of 4 openings	Not applicable	20 % of rated short circuit current [a]
Line charging (LC)	20 CO	3,0	100 % rated line charging
Cable charging (CC)	20 CO	2,0	100 % rated cable charging

[a] Preconditioning tests may be performed at reduced voltage provided that the average of the arcing times for the first-pole-to-clear of the 4 interruption tests at reduced voltage shall be at least 80 % of the average of the arcing times for the first-pole-to-clear found during test-duty T20 when performed at rated voltage.

Re-ignitions during the capacitive current switching tests are permitted.

For each test the arcing time should be set randomly.

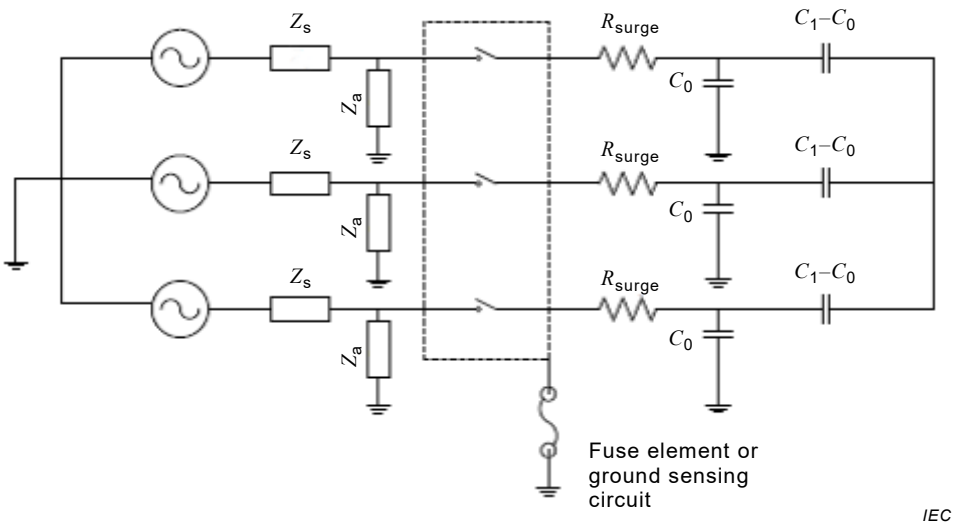

Figure 2a – Three-phase circuit

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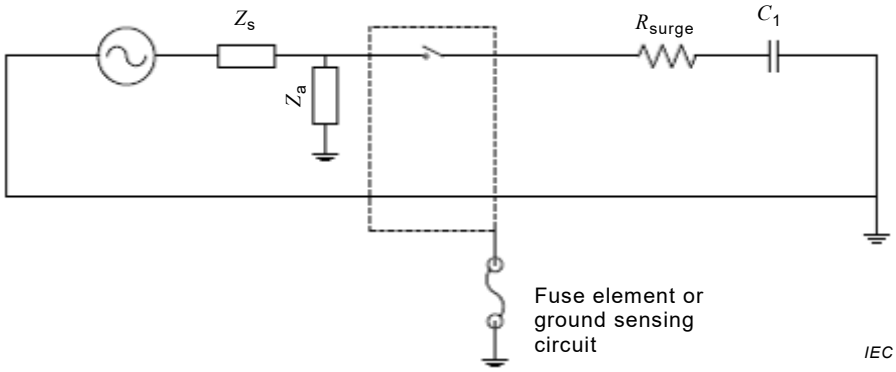

Figure 2b – Single-phase circuit

Key

Z_s Source impedance, see 7.101.3

Z_a Impedance of TRV circuit

C_0 Load capacitance to ground used to establish the C_1/C_0 ratio, see 7.101.4

C_1 Load capacitance to determine test current, see 7.101.4

R_{surge} Resistance in series with capacitive load to simulate surge impedance of line or cable, see 6.101.4

Figure 2 – Test circuits for cable-charging or line-charging switching tests (see 7.101.5)

7.101.9 Criteria to pass the test

7.101.9.1 General

The behaviour of the recloser during making and breaking of the capacitive currents in all prescribed test duties shall fulfil the conditions given in 7.112 once the contacts have fully separated and come to rest. The recloser shall pass both the LC and CC tests.

7.101.9.2 Restrike limitations

The recloser shall have successfully passed the tests if no more than three operations have restrikes during the combined LC and CC tests. Restrikes that occur within the first 0,3 s from initial clearing shall count towards the three restrike maximum; tests that withstand for 0,3 s, but restrike after 0,3 s shall be considered invalid and shall be repeated.

Disruptive discharges to the recloser enclosure or frame are not permitted. (See ground current monitoring in Figure 2.)

7.102 Making current capability

7.102.1 Test procedure

The standard operating duty test in 7.103.4 demonstrates the capability of the recloser interrupting gap to close and latch on the rated short-circuit making current of the recloser. If the recloser is equipped with a non-interrupting gap that may be closed into a fault, fault making capability shall be demonstrated by a separate test for each additional gap, e.g. cutout reclosers.

Demonstration of the making current capability for non-interrupting gaps shall be in a fault closing test using the method of closing intended for that gap. The recloser shall be closed at the rated maximum voltage and rated short-circuit breaking current given in 5.102. Three closing operations without maintenance shall be performed on the same object.

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