

INTERNATIONAL STANDARD



High-voltage switchgear and controlgear – Part 37-013: Alternating-current generator circuit-breakers



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CONTENTS

CONTENTS	2
FOREWORD	12
1 General	14
1.1 Scope	14
1.2 Normative references	14
2 Normal and special service conditions	15
2.1 Normal service conditions	15
2.2 Special service conditions	15
3 Terms and definitions	15
3.1 General terms	16
3.2 Assemblies of switchgear and controlgear	18
3.3 Parts of assemblies	18
3.4 Switching devices	18
3.5 Parts of generator circuit-breakers	20
3.6 Operation	23
3.7 Characteristic quantities	25
3.8 Index of definitions	40
4 Ratings	44
4.1 Rated voltage U_r	44
4.2 Rated insulation level	44
4.2.101 Dielectric strength	45
4.2.102 Rated power frequency withstand voltage U_d	45
4.2.103 Rated lightning impulse withstand voltage U_p	45
4.3 Rated frequency f_r	45
4.4 Rated normal current I_r and temperature rise	45
4.4.1 Rated normal current I_r	45
4.4.2 Temperature rise	46
4.4.3 Particular points of Table 3 of IEC 62271-1:2007	46
4.4.101 Emergency current ratings during loss of cooling	46
4.5 Rated short-time withstand current I_k	47
4.6 Rated peak withstand current I_p	47
4.7 Rated duration of short circuit t_k	47
4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits U_a	48
4.8.1 General	48
4.8.2 Rated supply voltage U_a	48
4.8.3 Tolerances	48
4.8.4 Ripple voltage	49
4.8.5 Voltage drop and supply interruption	49
4.9 Rated supply frequency of closing and opening devices and auxiliary circuits	49
4.10 Rated pressure of compressed gas supply for controlled pressure systems	49
4.11 Rated filling levels for insulation, interruption and/or operation	49
4.101 Rated short-circuit current	50
4.101.1 General	50
4.101.2 Rated system-source short-circuit breaking current	50

4.101.3	Rated generator-source short-circuit breaking current	52
4.101.4	Rated single-phase-to-earth fault breaking current	54
4.102	Rated peak short-circuit making current I_{MC}	54
4.103	Rated load making and breaking current	54
4.104	Rated out-of-phase making and breaking current	55
4.105	Rated transient recovery voltage (TRV) related to the breaking currents	55
4.105.1	Representation of TRV waves	55
4.105.2	Rated values of TRV	56
4.106	Standard operating sequence	57
4.106.1	General	57
4.106.2	Rated short-circuit current operating sequence	58
4.106.3	Rated load current operating sequence	58
4.106.4	Rated out-of-phase current operating sequence	58
4.107	Rated time quantities	58
4.107.1	General	58
4.107.2	Rated break-time	58
4.107.3	Rated minimum opening time	59
4.108	Mechanical operation endurance capability classes M1 and M2	59
5	Design and construction	59
5.1	Requirements for liquids in generator circuit-breakers	59
5.2	Requirements for gases in generator circuit-breakers	60
5.3	Earthing of generator circuit-breakers	60
5.4	Auxiliary and control equipment	60
5.5	Dependent power operation	61
5.6	Stored energy operation	61
5.7	Independent manual or power operation (independent unlatched operation)	61
5.8	Operation of releases	61
5.8.1	Shunt closing release	61
5.8.2	Shunt opening release	61
5.8.3	Capacitor operation of shunt releases	61
5.8.4	Under-voltage release	61
5.8.101	Multiple releases	61
5.8.102	Operation limits of releases	61
5.8.103	Power consumption of releases	61
5.9	Low- and high-pressure interlocking devices	62
5.10	Nameplates	62
5.10.101	Accessories	64
5.10.102	Modification of generator circuit-breakers	64
5.11	Interlocking devices	64
5.12	Position indication	64
5.13	Degrees of protection provided by enclosures	64
5.13.1	Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects (IP coding)	65
5.13.2	Protection against ingress of water (IP coding)	65
5.13.3	Protection of equipment against mechanical impact under normal service conditions (IK coding)	65
5.14	Creepage distances for outdoor insulators	65
5.15	Gas and vacuum tightness	65
5.16	Liquid tightness	65

5.17	Fire hazard (flammability).....	65
5.18	Electromagnetic compatibility (EMC).....	65
5.19	X-ray emission	65
5.20	Corrosion.....	65
5.101	Requirements for simultaneity of poles during single closing and single opening operations.....	65
5.102	General requirement for operation	66
5.103	Pressure limits of fluids for operation	66
5.104	Vent outlets	66
5.105	Warning labels	66
5.106	Instructions	66
6	Type tests	67
6.1	General.....	68
6.1.1	Grouping of tests	68
6.1.2	Information for identification of specimens	68
6.1.3	Information to be included in type-test reports	68
6.2	Dielectric tests	68
6.2.1	Ambient air conditions during tests	68
6.2.2	Wet test procedure.....	69
6.2.3	Condition of the generator circuit-breaker during dielectric tests.....	69
6.2.4	Criteria to pass the test.....	69
6.2.5	Application of test voltage and test conditions.....	69
6.2.6	Tests of generator circuit-breakers of $U_r \leq 245$ kV	69
6.2.7	Tests of generator circuit-breakers of $U_r > 245$ kV	70
6.2.8	Artificial pollution tests for outdoor insulators.....	70
6.2.9	Partial discharge tests.....	70
6.2.10	Dielectric tests on auxiliary and control circuits	70
6.2.11	Voltage test as a condition check	70
6.3	Radio interference voltage (r.i.v.) tests	70
6.4	Measurement of the resistance of circuits	71
6.4.1	Main circuit.....	71
6.4.2	Auxiliary circuits.....	71
6.5	Temperature-rise tests	71
6.5.1	Conditions of the generator circuit-breaker to be tested	71
6.5.2	Arrangement of the equipment	71
6.5.3	Measurement of the temperature and the temperature rise.....	73
6.5.4	Ambient air temperature	73
6.5.5	Temperature-rise tests of the auxiliary and control equipment.....	73
6.5.6	Interpretation of the temperature-rise tests	74
6.5.101	Demonstrations of emergency conditions.....	74
6.6	Short-time withstand current and peak withstand current tests	74
6.6.1	Arrangement of the generator circuit-breaker and of the test circuit.....	74
6.6.2	Test current and duration	74
6.6.3	Behaviour of generator circuit-breaker during test.....	74
6.6.4	Conditions of generator circuit-breaker after test.....	74
6.7	Verification of the degree of protection	75
6.7.1	Verification of the IP coding.....	75
6.7.2	Verification of the IK coding.....	75
6.8	Tightness tests.....	75



6.9	Electromagnetic compatibility (EMC) tests	75
6.10	Additional tests on auxiliary and control circuits	75
6.10.1	General	75
6.10.2	Functional tests	75
6.10.3	Electrical continuity of earthed metallic parts test.....	75
6.10.4	Verification of the operational characteristics of auxiliary contacts.....	75
6.10.5	Environmental tests	75
6.10.6	Dielectric tests	76
6.11	X-radiation test procedure for vacuum interrupters	76
6.101	Mechanical and environmental tests	76
6.101.1	Miscellaneous provisions for mechanical and environmental tests	76
6.101.2	Mechanical operation test at ambient air temperature	79
6.101.3	Low and high temperature tests.....	81
6.101.4	Sound level tests	85
6.102	Miscellaneous provisions for making and breaking tests.....	85
6.102.1	General	85
6.102.2	Number of test specimens	86
6.102.3	Arrangement of generator circuit-breaker for tests	86
6.102.4	General considerations concerning testing methods.....	88
6.102.5	Synthetic tests	94
6.102.6	No-load operations before tests.....	94
6.102.7	Alternative operating mechanisms	94
6.102.8	Behaviour of generator circuit-breaker during tests	95
6.102.9	Condition of generator circuit-breaker after tests.....	96
6.102.10	Demonstration of the most severe switching conditions.....	98
6.102.11	Methods of determining prospective transient recovery voltage waves.....	115
6.103	System-source short-circuit making and breaking tests	115
6.103.1	Power factor of test circuit.....	115
6.103.2	Frequency of test circuit.....	115
6.103.3	Earthing of test circuit	115
6.103.4	Connection of test circuit to generator circuit-breaker.....	117
6.103.5	Applied voltage for system-source short-circuit making tests	117
6.103.6	System-source short-circuit making current	117
6.103.7	System-source short-circuit breaking current	117
6.103.8	Transient recovery voltage (TRV) for system-source short-circuit breaking tests	118
6.103.9	Measurement of transient recovery voltage during test.....	119
6.103.10	Power frequency recovery voltage.....	119
6.103.11	System-source short-circuit test operating sequence.....	119
6.103.12	System-source short-circuit test-duties	119
6.104	Load current breaking tests	121
6.104.1	General	121
6.104.2	Conditions of test severity	122
6.104.3	Number of tests	122
6.105	Generator-source short-circuit current making and breaking tests.....	122
6.105.1	Power factor of test circuit.....	122
6.105.2	Frequency of test circuit.....	122
6.105.3	Earthing of test circuit	123
6.105.4	Connection of the test circuit to the generator circuit-breaker	123

6.105.5	Applied voltage for generator-source short-circuit making tests	123
6.105.6	Generator-source short-circuit making current	124
6.105.7	Generator-source short-circuit breaking current	124
6.105.8	Transient recovery voltage (TRV) for generator-source short-circuit breaking tests	125
6.105.9	Measurement of transient recovery voltage during test.....	125
6.105.10	Power frequency recovery voltage	125
6.105.11	Generator-source short-circuit test operating sequence	125
6.105.12	Generator-source short-circuit breaking test-duties	125
6.106	Out-of-phase making and breaking tests	131
6.106.1	General	131
6.106.2	Out-of-phase current switching capability.....	132
6.106.3	Conditions of test severity	132
6.106.4	Test circuit.....	134
6.106.5	Applied voltage before out-of-phase making tests	136
6.106.6	Transient recovery voltage (TRV) for out-of-phase breaking tests.....	136
6.106.7	Demonstration of the most severe switching conditions during test-duty OP1	136
6.106.8	Demonstration of the most severe switching conditions during test-duty OP2	136
7	Routine tests	136
7.1	Dielectric test on the main circuit	137
7.2	Tests on auxiliary and control circuits	137
7.2.1	Inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams	137
7.2.2	Functional tests	137
7.2.3	Verification of protection against electrical shock	137
7.2.4	Dielectric tests	137
7.3	Measurement of the resistance of the main circuit.....	138
7.4	Tightness test	138
7.4.1	Controlled pressure systems for gas.....	138
7.4.2	Closed pressure systems for gas.....	138
7.4.3	Sealed pressure systems	138
7.4.4	Liquid tightness tests	138
7.5	Design and visual checks	139
7.101	Mechanical operating tests	139
8	Guide to the selection of generator circuit-breakers	140
8.101	General.....	140
8.102	General application conditions.....	141
8.102.1	Normal service conditions	141
8.102.2	Special service conditions	141
8.103	Application consideration	143
8.103.1	General	143
8.103.2	Rated voltage	143
8.103.3	Rated insulation level.....	143
8.103.4	Rated frequency.....	144
8.103.5	Rated normal current	144
8.103.6	Short-circuit current rating.....	144
8.103.7	TRV rating for system-source and generator-source short-circuits	159
8.103.8	Rated load making and breaking current.....	165

8.103.9	Rated out-of-phase making and breaking current	169
8.103.10	Excitation switching current	170
8.103.11	Capacitive switching current	171
9	Information to be given with enquiries, tenders and orders	171
10	Rules for transport, storage, installation, operation and maintenance	173
10.1	Conditions during transport, storage and installation	173
10.2	Installation	174
10.2.1	Unpacking and lifting	174
10.2.2	Assembly	174
10.2.3	Mounting	174
10.2.4	Connections	174
10.2.5	Final installation inspection	174
10.2.6	Basic input data by the user	175
10.2.7	Basic input data by the manufacturer	175
10.2.101	Commissioning tests	175
10.2.102	Commissioning checks and test programme	176
10.3	Operation	179
10.4	Maintenance	180
10.4.1	General	180
10.4.2	Recommendations for the manufacturer	180
10.4.3	Recommendations for the user	181
10.4.4	Failure report	181
11	Safety	183
11.1	Precautions by manufacturers	183
11.2	Precautions by users	183
11.3	Electrical aspects	184
11.4	Mechanical aspects	184
11.5	Thermal aspects	185
11.6	Operation aspects	185
12	Influence of the product on the environment	185
Annex A (normative)	Tolerances on test quantities during type tests	186
Annex B (normative)	Records and reports of type tests according to 6.6, 6.103, 6.104, 6.105 and 6.106	190
B.1	Information and results to be recorded	190
B.2	Information to be included in type test reports	190
B.2.1	General	190
B.2.2	Apparatus tested	190
B.2.3	Rated characteristics of generator circuit-breaker, including its operating devices and auxiliary equipment	190
B.2.4	Test conditions (for each series of tests)	191
B.2.5	Short-circuit making and breaking tests	191
B.2.6	Short-time withstand current test	192
B.2.7	No-load operation	192
B.2.8	Out-of-phase making and breaking tests	192
B.2.9	Load current switching tests	193
B.2.10	Oscillographic and other records	193
Annex C (...)		194
Annex D (normative)	Use of mechanical characteristics and related requirements	194

Annex E (informative) Example of the application of a generator circuit-breaker	196
E.1 General	196
E.2 System characteristics	196
E.3 System-source short-circuit current	198
E.3.1 AC component of the system-source short-circuit breaking current	198
E.3.2 System-source asymmetrical short-circuit breaking current	199
E.4 Generator-source short-circuit current	201
E.4.1 AC component of the generator-source short-circuit breaking current	201
E.4.2 Generator-source asymmetrical short-circuit breaking current	202
E.5 Transient recovery voltage	204
E.6 Out-of-phase conditions	204
E.7 Normal current application	207
E.8 Generator circuit-breaker electrical characteristics	208
Annex F (informative) For generator circuit-breakers connected to the step-up transformer by shielded cables - An example of the effects of added capacitance on TRV requirements for a system-source fault	210
Annex G (informative) Symbols and related terminology	213
G.1 Comparison of IEEE and IEC electrical terms and symbols	213
G.2 Comparison between TRV terminology and symbols	214
Annex H (informative) Determination of the degree of asymmetry for generator-source short-circuit breaking tests	216
Annex I (informative) Faults in case of three-winding step-up transformer	218
Bibliography	221
 Figure 1 – Typical oscillogram of a three-phase short-circuit make-break cycle	35
Figure 2 – Generator circuit-breaker without resistors – Opening operation	36
Figure 3 – Generator circuit-breaker without resistors – Close-open cycle	36
Figure 4 – Generator circuit-breaker with opening resistors – Opening operation	37
Figure 5 – Generator circuit-breaker with opening resistors – Close-open cycle	37
Figure 6 – Example of a three-phase asymmetrical current	38
Figure 7 – Examples of possible valid interruptions in a phase with intermediate level of asymmetry after a major loop and a corresponding time t_1	39
Figure 8 – Examples of possible valid interruptions in a phase with intermediate level of asymmetry after a minor loop and a corresponding time t_2	40
Figure 9 – Effect of various cooling failures and subsequent load reductions on generator circuit-breaker temperature	47
Figure 10 – Typical asymmetrical system-source short-circuit current	51
Figure 11 – Degree of asymmetry as a function of time after fault initiation	52
Figure 12 – Typical asymmetrical generator-source short-circuit current with a strong decrement of the a.c. component	53
Figure 13 – 2-parameter representation of prospective TRV waveform for interrupting three-phase symmetrical faults	56
Figure 14 – Typical temperature rise test setup for single-phase-enclosed generator circuit-breakers (top view)	73
Figure 15 – Test sequences for low and high temperature tests	85
Figure 16 – Reference mechanical travel characteristics (idealised curve)	89

Figure 17 – Reference mechanical travel characteristics (idealised curve) with the prescribed envelopes centered over the reference curve (+5 %, –5 %), contact separation in this example at time $t = 20$ ms	90
Figure 18 – Reference mechanical travel characteristics (idealised curve) with the prescribed envelopes fully displaced upward from the reference curve (+10 %, –0 %), contact separation in this example at time $t = 20$ ms	90
Figure 19 – Reference mechanical travel characteristics (idealised curve) with the prescribed envelopes fully displaced downward from the reference curve (+0 %, –10 %), contact separation in this example at time $t = 20$ ms	91
Figure 20 – Equivalent testing set-up for unit testing of generator circuit-breakers with more than one separate interrupter units	92
Figure 21 – Two valid three-phase symmetrical breaking operations	100
Figure 22 – Three-phase asymmetrical breaking operations – Minimum arcing time with intermediate asymmetry after major loop ($t_{\text{arc min 1}}$)	102
Figure 23 – Three-phase asymmetrical breaking operations – Maximum arcing time for the first-pole-to-clear after major loop ($t_{\text{arc max 1}}$)	103
Figure 24 – Three-phase asymmetrical breaking operations – Minimum arcing time with intermediate asymmetry after minor loop ($t_{\text{arc min 2}}$)	104
Figure 25 – Three-phase asymmetrical breaking operations – Maximum arcing time for the last-pole-to-clear after extended major loop ($t_{\text{arc max 2}}$)	105
Figure 26 – Single-phase asymmetrical breaking operations – Minimum arcing time with intermediate asymmetry after major loop ($t_{\text{arc min 1}}$)	107
Figure 27 – Single-phase asymmetrical breaking operations – Maximum arcing time for the first-pole-to-clear after major loop ($t_{\text{arc max 1}}$)	108
Figure 28 – Single-phase asymmetrical breaking operations – Minimum arcing time with intermediate asymmetry after minor loop ($t_{\text{arc min 2}}$)	109
Figure 29 – Single-phase asymmetrical breaking operations – Maximum arcing time for the last-pole-to-clear extended major loop ($t_{\text{arc max 2}}$)	110
Figure 30 – Earthing of test circuits for three-phase short-circuit tests, first-pole-to-clear factor 1,5	116
Figure 31 – Earthing of test circuits for single-phase short-circuit tests, first-pole-to-clear factor 1,5	116
Figure 32 – Example of a valid prospective test current for test-duty 5	126
Figure 33 – Example of a valid test for test-duty 5	126
Figure 34 – Example of an invalid test for test-duty 5	127
Figure 35 – Second example of a valid test for test-duty 5	127
Figure 36 – Example of a valid prospective test current for test-duties 6A and 6B	128
Figure 37 – Example of a valid test for test-duties 6A and 6B	128
Figure 38 – Example of a valid test for test-duties 6A and 6B	129
Figure 39 – Test circuit for single-phase out-of-phase tests	135
Figure 40 – Test circuit for out-of-phase tests using two voltages separated by 120 electrical degrees	135
Figure 41 – Test circuit for out-of-phase tests with one terminal of the generator circuit-breaker earthed (subject to agreement of the manufacturer)	135
Figure 42 – General circuit diagram of a power station	145
Figure 43 – Generator-source short-circuit current	147
Figure 44 – Generator-source short-circuit current in case of generator delivering power with lagging or leading power factor prior to fault initiation	148
Figure 45 – Short-circuit current for generator-source fault	149

Figure 46 – Short-circuit current with circuit-breaker arc voltage after contact separation.....	150
Figure 47 – Single-line diagram of a power station with two generators connected to the high-voltage system by means of a three-winding step-up transformer	159
Figure 48 – Single-line diagram of unit generator system.....	161
Figure 49 – Single-line diagram of half-sized transformer unit system	161
Figure 50 – Single-line diagram of system with half-sized generators	162
Figure 51 – Single-line diagram of power system	166
Figure 52 – Equivalent circuit of power system.....	166
Figure 53 – Voltage diagram for lagging power factor load	167
Figure 54 – Voltage diagram for unity power factor load.....	167
Figure 55 – Recovery voltage across the generator circuit-breaker	167
Figure 56 – TRV curve for the first-pole-to-clear.....	168
Figure E.1 – Single-line station diagram	196
Figure E.2 – Asymmetrical generator-source short-circuit current with no arc at the fault location	203
Figure E.3 – Asymmetrical generator-source short-circuit current with arc at the fault location	204
Figure E.4 – Schematic diagram of power station (single-line diagram as in Figure 48)	205
Figure E.5 – Prospective fault current considering the moment of inertia of the synchronous machine and resulting from synchronizing under out-of-phase conditions (out-of-phase angle $\varphi_0 = 90^\circ$, fault initiation at $U_A = 0$).....	207
Figure E.6 – Generator circuit-breaker temperature and load current with loss of coolant	208
Figure F.1 – TRV rate-of-rise for system-source faults: transformers rated from 65,5 MVA to 100 MVA	211
Figure F.2 – TRV peak (u_c) multipliers for system-source faults: transformers rated from 65,5 MVA to 100 MVA	211
Figure F.3 – TRV rate-of-rise for system-source faults: transformers rated from 10 MVA to 50 MVA	212
Figure F.4 – TRV peak (u_c) multipliers for system-source faults: transformers rated from 10 MVA to 50 MVA.....	212
Figure G.1 – 2-parameter TRV envelope representation of 1-cosine TRV when interrupting three-phase symmetrical fault currents.....	215
Figure H.1 – Prospective generator-source short-circuit current (fault initiation at voltage zero)	217
Figure I.1 – Single-line diagram of a power station with two generators connected to the high-voltage system by means of a three-winding step-up transformer	218
Figure I.2 – Prospective system-source short-circuit current to be interrupted by Generator circuit-breaker #1 in case of three-phase earthed fault occurring at location F in Figure I.1 (only the current in the phase with the highest degree of asymmetry is shown – fault initiation at voltage = 0)	219
Figure I.3 – Prospective fault current fed by Generator 2 to be interrupted by Generator circuit-breaker 2 in case of three-phase earthed fault occurring at location F in Figure I.1 (only the current in the phase with the highest degree of asymmetry is shown – fault initiation at voltage = 0)	220

Table 1 – Rated insulation levels for a.c. generator circuit-breakers	45
Table 2 – Preferred values of supply voltages and their ranges for closing and opening devices and of auxiliary and control circuits of generator circuit-breakers	49
Table 3 – TRV parameters for system-source faults	56
Table 4 – TRV parameters for generator-source faults	57
Table 5 – TRV parameters for load current switching	57
Table 6 – TRV parameters for out-of-phase current switching	57
Table 7 – Nameplate information	62
Table 8 – Type tests	68
Table 9 – Conditions during temperature rise test	72
Table 10 – Number of operating sequences	80
Table 11 – Operations to be performed before and after the test programme	80
Table 12 – Test parameters for 50 Hz asymmetrical system-source fault test-duties for the first-pole-to-clear	111
Table 13 – Test parameters for 60 Hz asymmetrical system-source fault test-duties for the first-pole-to-clear	112
Table 14 – Test parameters for 50 Hz asymmetrical system-source fault test-duties for the last-pole-to-clear	113
Table 15 – Test parameters for 60 Hz asymmetrical system-source fault test-duties for the last-pole-to-clear	114
Table 16 – Test duties to demonstrate the system-source short-circuit making and breaking current capability for three-phase tests	120
Table 17 – Test duties to demonstrate the system-source short-circuit making and breaking current capability for single-phase tests	121
Table 18 – Test duties to demonstrate the generator-source short-circuit making and breaking current capability for three-phase tests	130
Table 19 – Test duties to demonstrate the generator-source short-circuit making and breaking current capability for single-phase tests	131
Table 20 – Test duties to demonstrate the out-of-phase current switching capability for three-phase tests	133
Table 21 – Test duties to demonstrate the out-of-phase current switching capability for single-phase tests	134
Table A.1 – Tolerances on test quantities for type tests	187
Table E.1 – System characteristics	197
Table G.1 – Comparison of IEEE and IEC electrical terms and symbols	213
Table G.2 – A comparison between the TRV terminology and symbols used in IEC 62271-100 with those used in older IEEE/ANSI standards	215
Table I.1 – A comparison between prospective system-source short-circuit currents to be interrupted by Generator circuit-breaker 1 in case of three-phase earthed fault occurring at location F in Figure I.1	219

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 37-013: Alternating-current generator circuit-breakers

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This publication is published as an IEC/IEEE Dual Logo standard.

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

FDIS	Report on voting
17A/1074/FDIS	17A/1101/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 in the IEC 62271 series, published under the general title *High-voltage switchgear and controlgear*, can be found on the IEC website.

This standard shall be read in conjunction with IEC 62271-1: 2007, to which it refers and which is applicable unless otherwise specified in this standard. In order to simplify and clarify the structure of this document, the numbering of clauses and subclauses used here is the same as in IEC 62271-1. Amendments to these clauses and subclauses are given under the same numbering, while additional subclauses are numbered from 101.

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- replaced by a revised edition, or
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¹ A list of IEEE participants can be found at the following address:
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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 37-013: Alternating-current generator circuit-breakers

1 General

1.1 Scope

This part of IEC 62271 is applicable to three-phase a.c. high-voltage generator circuit-breakers, hereafter called generator circuit-breaker, designed for indoor or outdoor installation and for operation at frequencies of 50 Hz and 60 Hz on systems having voltages above 1 kV and up to 38 kV.

It is applicable to generator circuit-breakers that are installed between the generator and the transformer terminals. Requirements relative to generator circuit-breakers intended for use with generators and transformers rated 10 MVA or more are covered specifically. Generator circuits rated less than 10 MVA and pumped storage installations are considered special applications, and their requirements are not completely covered by this standard.

This standard is also applicable to the operating mechanisms of generator circuit-breakers and to their auxiliary equipment.

1.2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-441:1984, *International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses*

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

IEC 60296:2012, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60480:2004, *Guidelines for the checking and treatment of sulphur hexafluoride (SF₆) taken from electrical equipment and specification for its re-use*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 61180-1, *High-voltage test techniques for low voltage equipment – Part 1: Definitions, test and procedure requirements*

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

IEC 62271-1:2007, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-1:2007/AMD1:2011

IEC IEEE 62271-37-082:2012, *High-voltage switchgear and controlgear – Part 37-082: Standard practice for the measurement of sound pressure levels on alternating current circuit-breakers*

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-100:2008/AMD1:2012

IEC 62271-101:2012, *High-voltage switchgear and controlgear – Part 101: Synthetic testing*

IEC TR 62271-306:2012, *High-voltage switchgear and controlgear – Part 306: Guide to IEC 62271-100, IEC 62271-1 and other IEC standards related to alternating current circuit-breakers*

IEEE Std C37.011TM-2011, *IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers (ANSI)*²

IEEE Std C37.23TM-2003 (Reaff 2008), *IEEE Standard for Metal-Enclosed Bus (ANSI)*

IEEE Std C37.59TM-2007, *IEEE Standard Requirements for Conversion of Power Switchgear Equipment*

2 Normal and special service conditions

NOTE Normal and special service conditions are sometimes called usual and unusual service conditions respectively.

2.1 Normal service conditions

Subclause 2.1 of IEC 62271-1:2007 is applicable.

2.2 Special service conditions

Subclause 2.2 of IEC 62271-1:2007 is applicable.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in IEC 60050-441 and IEC 62271-1, as well as the following, apply.

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

The IEEE Standards Dictionary Online³ should be referenced for terms and definitions not defined in this clause.

For clarity, ease of reference and convenience of the user, definitions of selected terms as used in this standard are given below.

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³ IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

3.1 General terms

3.1.101

switchgear and controlgear

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

Note 1 to entry: Since generator circuit-breakers are used only in switchgear, this document will refer only to “switchgear” and not to “switchgear and controlgear”.

[SOURCE: IEC 60050-441:1984, 441-11-01, modified – Addition of a new note to entry.]

3.1.102

short-circuit current

over-current resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

[SOURCE: IEC 60050-441:1984, 441-11-07]

3.1.103

moment of inertia

sum (integral) of the products of the mass elements of a body and the squares of their distances (radii) from a given axis

3.1.104

out-of-phase conditions

abnormal circuit conditions of loss or lack of synchronism between the parts of an electrical system on either side of a generator circuit-breaker in which, at the instant of operation of the generator circuit-breaker, the phase angle between rotating vectors, representing the generated voltages on either side, exceeds the normal value

3.1.105

out-of-phase (as prefix to a characteristic quantity)

qualifying term indicating that the characteristic quantity is applicable to operation of the generator circuit-breaker in out-of-phase conditions

3.1.106

unit test

test made on a making or breaking unit or group of units at the making current or the breaking current, specified for the test on the complete pole of a generator circuit-breaker and at the appropriate fraction of the applied voltage, or the recovery voltage, specified for the test on the complete pole of the generator circuit-breaker

3.1.107

loop (of an a.c. current wave)

part of the wave of the a.c. current between two successive current zero crossings

SEE: Figure 1 *n* and *p*.

Note 1 to entry: When a d.c. component (see Figure 1 *d*) is present, a distinction is made between a major loop (see Figure 1 *n*) and a minor loop (see Figure 1 *p*) depending on the time interval between two successive current zero crossings being longer or shorter, respectively, than the half-period of the alternating component of the current.

3.1.108

power factor (of a circuit)

ratio of the resistance to the impedance at power frequency of an equivalent circuit supposed to be formed by an inductance and a resistance in series

3.1.109

external insulation

distances in air and the surfaces in contact with open air of solid insulation of the equipment, which are subject to dielectric stresses and to the effects of atmospheric and other conditions such as pollution, humidity, vermin, etc.

[SOURCE: IEC 60050-604:1987, 604-03-02, modified – replacement of "atmospheric air" by "air"]

3.1.110

self-restoring insulation

insulation which completely recovers its insulating properties after a disruptive discharge

[SOURCE: IEC 60050-604:1987, 604-03-04]

3.1.111

non-self-restoring insulation

insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge

[SOURCE: IEC 60050-604:1987, 604-03-05]

3.1.112

disruptive discharge

phenomenon associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

Note 1 to entry: This term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self-restoring insulation).

Note 3 to entry: The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

3.1.113

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

Note 1 to entry: Oscillations following NSDDs are associated with the parasitic capacitance and inductance local to or of the circuit-breaker itself. NSDDs may also involve the stray capacitance to earth of nearby equipment.

3.1.114

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

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 to be considered.

3.1.115

non-effectively earthed neutral system

system other than effectively earthed neutral system and not meeting its conditions

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 to be considered.

3.1.116

re-ignition (of an a.c. 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 less than a quarter cycle of power frequency

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

3.1.117

restrike (of an a.c. 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]

3.1.118

isolated-phase bus

bus in which each phase conductor is enclosed by an individual earthed metal housing separated from adjacent conductor housings by an air space

Note 1 to entry: The bus may be self-cooled or may be forced-cooled by means of circulating gas or liquid.

3.2 Assemblies of switchgear and controlgear

No particular definitions.

3.3 Parts of assemblies

No particular definitions.

3.4 Switching devices

3.4.101

switching device

device designed to make or break the current in one or more electric circuits

[SOURCE: IEC 60050-441:1984, 441-14-01]

3.4.102

mechanical switching device

switching device designed to close and open one or more electric circuits by means of separable contacts

Note 1 to entry: Any mechanical switching device may be designated according to the medium in which its contacts open and close, e.g. air, SF₆, oil.

[SOURCE: IEC 60050-441:1984, 441-14-02]

3.4.103

circuit-breaker

mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit, as well as capable of withstanding specified voltages across the gap between the contacts when open

[SOURCE: IEC 60050-441:1984, 441-14-20, modified – addition of a new capability]

3.4.104

generator circuit-breaker

circuit-breaker installed between generator and associated step-up transformer

3.4.105

air circuit-breaker

circuit-breaker in which the contacts open and close in air at atmospheric pressure

[SOURCE: IEC 60050-441:1984, 441-14-27]

3.4.106

oil circuit-breaker

circuit-breaker in which the contacts open and close in oil

Note 1 to entry: Typical examples of oil circuit-breakers are live tank minimum oil circuit-breakers and dead tank bulk oil circuit-breakers.

[SOURCE: IEC 60050-441:1984, 441-14-28]

3.4.107

vacuum circuit-breaker

circuit-breaker in which the contacts open and close within a highly evacuated envelope

[SOURCE: IEC 60050-441:1984, 441-14-29]

3.4.108

gas-blast circuit-breaker

circuit-breaker in which the arc develops in a blast of gas

Note 1 to entry: Where the gas is moved by a difference in pressure established by mechanical means during the opening operation of the circuit-breaker, it is termed a single pressure gas-blast circuit-breaker. Where the gas is moved by a difference in pressure established before the opening operation of the circuit-breaker, it is termed a double pressure gas-blast circuit-breaker.

[SOURCE: IEC 60050-441:1984, 441-14-30]

3.4.109

(void)

3.4.110

air-blast circuit-breaker

gas-blast circuit-breaker in which the gas used is air

[SOURCE: IEC 60050-441:1984, 441-14-32]

3.4.111

generator circuit-breaker class M1

generator circuit-breaker with normal mechanical endurance

3.4.112

generator circuit-breaker class M2

frequently operated generator circuit-breaker for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests

3.4.113

generator circuit-breaker class G1

generator circuit-breaker having a rated generator-source short-circuit breaking current characterized at contact separation by a degree of asymmetry of 110 % with the assigned a.c. component of the rated generator-source short-circuit breaking current and a degree of asymmetry of 130 % with a current having an a.c. component equal to 74 % of the assigned a.c. component of the rated generator-source short-circuit breaking current

3.4.114

generator circuit-breaker class G2

generator circuit-breaker having a rated generator-source short-circuit breaking current characterized at contact separation by a degree of asymmetry of 130 % with the assigned a.c. component of the rated generator-source short-circuit breaking current

3.5 Parts of generator circuit-breakers

3.5.101

pole

portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together

Note 1 to entry: A switching device is called single-pole if it has only one pole. If it has more than one pole, it may be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

[SOURCE: IEC 60050-441:1984, 441-15-01]

3.5.102

main circuit

all the conductive parts of a switching device included in the circuit which it is designed to close or open

[SOURCE: IEC 60050-441:1984, 441-15-02]

3.5.103

control circuit

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

[SOURCE: IEC 60050-441:1984, 441-15-03]

3.5.104

auxiliary circuit

all the conductive parts of a switching device which are intended to be included in a circuit other than the main circuit and the control circuits of the device

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

[SOURCE: IEC 60050-441:1984, 441-15-04]

3.5.105

contact

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

[SOURCE: IEC 60050-441:1984, 441-15-05]

3.5.106

main contact

contact included in the main circuit of a mechanical switching device, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:1984, 441-15-07]

3.5.107

arcing contact

contact on which the arc is intended to be established

Note 1 to entry: An arcing contact may serve as a main contact; it may be a separate contact so designed that it opens after and closes before another contact which it is intended to protect from injury.

[SOURCE: IEC 60050-441:1984, 441-15-08]

3.5.108

control contact

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

[SOURCE: IEC 60050-441:1984, 441-15-09]

3.5.109

auxiliary contact

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

[SOURCE: IEC 60050-441:1984, 441-15-10]

3.5.110

auxiliary switch

switch containing one or more control and/or auxiliary contacts mechanically operated by a switching device

[SOURCE: IEC 60050-441:1984, 441-15-11]

3.5.111

“a” contact

make contact

control or auxiliary contact which is closed when the main contacts of the mechanical switching device are closed and open when they are open

[SOURCE: IEC 60050-441:1984, 441-15-12]

3.5.112

“b” contact

break contact

control or auxiliary contact which is open when the main contacts of a mechanical switching device are closed and closed when they are open

[SOURCE: IEC 60050-441:1984, 441-15-13]

3.5.113

release

device, mechanically connected to a mechanical switching device, which releases the holding means and permits the opening or the closing of the switching device

[SOURCE: IEC 60050-441:1984, 441-15-17]

3.5.114

arc control device

device, surrounding the arcing contacts of a mechanical switching device, designed to confine the arc and to assist in its extinction

[SOURCE: IEC 60050-441:1984, 441-15-18]

3.5.115

position indicating device

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

[SOURCE: IEC 60050-441:1984, 441-15-25]

3.5.116

connection (bolted or equivalent)

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

3.5.117

terminal

component provided for the connection of a device to external conductors

3.5.118

making (or breaking) unit

part of a generator circuit-breaker which in itself acts as a circuit-breaker and which, in series with one or more identical and simultaneously operated making or breaking units, forms the complete generator circuit-breaker

Note 1 to entry: Making units and breaking units may be separate or combined. Each unit may have several contacts.

Note 2 to entry: The means controlling the voltage distribution between units may differ from unit to unit.

3.5.119

module

assembly which generally comprises making or breaking units, post-insulators and mechanical parts and which is mechanically and electrically connected to other identical assemblies to form a pole of a generator circuit-breaker

3.5.120

enclosure

part of a generator circuit-breaker providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

Note 1 to entry: A three-phase enclosed generator circuit-breaker has all three phases in a common enclosure.

Note 2 to entry: A single-phase enclosed generator circuit-breaker has each phase in a single independent enclosure.

Note 3 to entry: For degrees of protection specified by IP coding see IEC 60529:1989 and for degrees of protection specified by IK coding see IEC 62262:2002.

[SOURCE: IEC 60050-441:1984, 441-13-01, modified – addition of new notes to entry and replacement of "assembly" by "generator circuit-breaker" in the definition]

3.5.121

operating mechanism

part of the generator circuit-breaker that actuates the main contacts

3.5.122

power kinematic chain

mechanical connecting system from and including the operating mechanism up to and including the moving contacts

3.5.123

alternative operating mechanism

mechanism obtained when a change in the power kinematic chain of the original operating mechanism or the use of an entirely different operating mechanism leads to the same mechanical characteristics.

Note 1 to entry: Mechanical characteristics are defined in 6.101.1.1. The use of mechanical characteristics and related requirements are described in Annex D.

Note 2 to entry: An alternative operating mechanism can utilise an operating principle different from the original one (for example the alternative mechanism can be spring-operated and the original hydraulic).

Note 3 to entry: A change in the secondary equipment does not lead to an alternative operating mechanism. However, changes in the opening time can entail differences for asymmetrical switching conditions.

3.6 Operation

3.6.101

operation

transfer of the moving contact(s) from one position to an adjacent position

Note 1 to entry: For a generator circuit-breaker, this can be a closing operation or an opening operation.

Note 2 to entry: If distinction is necessary, an operation in the electrical sense, e.g. make or break, is referred to as a switching operation, and an operation in the mechanical sense, e.g. close or open, is referred to as a mechanical operation.

[SOURCE: IEC 60050-441:1984, 441-16-01]

3.6.102

operating cycle

succession of operations from one position to another and back to the first position through all other positions, if any

[SOURCE: IEC 60050-441:1984, 441-16-02]

3.6.103

operating sequence

succession of specified operations with specified time intervals

[SOURCE: IEC 60050-441:1984, 441-16-03]

3.6.104

closing operation

C

operation by which the device is brought from the open position to the closed position

[SOURCE: IEC 60050-441:1984, 441-16-08]

3.6.105
opening operation

O
operation by which the device is brought from the closed position to the open position

[SOURCE: IEC 60050-441:1984, 441-16-09]

3.6.106
stored energy operation

operation by means of energy stored in the mechanism itself prior to the completion of the operation and sufficient to complete it under predetermined conditions

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

- a) The manner of storing the energy (spring, weight, etc.);
- b) The origin of the energy (manual, electric, etc.);
- c) The manner of releasing the energy (manual, electric, etc.).

3.6.107
closed position

position in which the predetermined continuity of the main circuit of the device is secured

[SOURCE: IEC 60050-441:1984, 441-16-22]

3.6.108
open position

position in which the predetermined clearance between open contacts in the main circuit of the device is secured

[SOURCE: IEC 60050-441:1984, 441-16-23]

3.6.109
trip-free mechanical switching device

mechanical switching device, the moving contacts of which return to and remain in the open position when the opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained

Note 1 to entry: To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

Note 2 to entry: If the release circuit is completed through an auxiliary switch, electrical release will not take place until such auxiliary switch is closed.

[SOURCE: IEC 60050-441:1984, 441-16-31, modified – addition of a second note to entry]

3.6.110
shunt release

release energized by a source of voltage

[SOURCE: IEC 60050-441:1984, 441-16-41]

3.6.111
anti-pumping device

device which prevents reclosing after a close-open operation as long as the device initiating closing is maintained in the position for closing

[SOURCE: IEC 60050-441:1984, 441-16-48]

3.6.112

interlocking device

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

[SOURCE: IEC 60050-441:1984, 441-16-49]

3.6.113

making operation

closing operation while power is applied to the main circuit

Note 1 to entry: See Figure 1.

3.6.114

breaking operation

opening operation while power is applied to the main circuit

Note 1 to entry: See Figure 1.

3.6.115

close-open operation

CO

closing operation followed by an opening operation

3.6.116

make-break operation

close-open operation while power is applied to the main circuit

Note 1 to entry: See Figure 1.

3.7 Characteristic quantities

Figures 1 to 5 illustrate some definitions of this subclause.

Time quantities, see terms and definitions 3.7.126 to 3.7.135, are expressed in milliseconds or in cycles of the rated power frequency. When expressed in cycles, the power frequency should be stated in brackets. In the case of generator circuit-breakers incorporating switching resistors, a distinction is made, where applicable, between time quantities associated with the contacts switching the full current and the contacts switching the current limited by switching resistors.

Unless otherwise stated, the time quantities referred to are associated with the contacts switching the full current.

3.7.101

rated value

quantity value assigned, generally by a manufacturer, for a specified operating condition of component, device or equipment

3.7.102

prospective current (of a circuit and with respect to a switching device or a fuse)

current that would flow in the circuit if each pole of the switching device or the fuse were replaced by a conductor of negligible impedance

Note 1 to entry: The method to be used to evaluate and to express the prospective current is to be specified in the relevant publications.

[SOURCE: IEC 60050-441:1984, 441-17-01]

3.7.103

prospective peak current

peak value of the first major loop of the prospective current during the transient period following initiation

Note 1 to entry: The definition assumes that the current is made by an ideal generator circuit-breaker, i.e. with instantaneous and simultaneous transition of its impedance across the terminals of each pole from infinity to zero. The peak value may differ from one pole to another; it depends on the instant of current initiation relative to the voltage wave across the terminals of each pole.

3.7.104

peak current

peak value of the first major loop of current during the transient period following initiation

Note 1 to entry: See Figure 1 *a*.

3.7.105

prospective symmetrical current (of an a.c. circuit)

prospective current when it is initiated at such an instant that no transient phenomenon follows the initiation

Note 1 to entry: For polyphase circuits, the condition of non-transient period can only be satisfied for the current in one pole at a time.

Note 2 to entry: The prospective symmetrical current is expressed by its r.m.s.

[SOURCE: IEC 60050-441:1984, 441-17-03]

3.7.106

maximum prospective peak current (of an a.c. circuit)

prospective peak current when initiation of the current takes place at the instant which leads to the highest possible value

Note 1 to entry: For a multiple device in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

[SOURCE: IEC 60050-441:1984, 441-17-04]

3.7.107

prospective making current (for a pole of a switching device)

prospective current when initiated under specified conditions

Note 1 to entry: The specified conditions may relate to the method of initiation, e.g. by an ideal switching device, or to the instant of initiation, e.g. leading to the maximum prospective peak current in an a.c. circuit, or to the highest rate of rise. The specification of these conditions is found in the relevant publications.

[SOURCE: IEC 60050-441:1984, 441-17-05]

3.7.108

making current

peak making current

peak value of the first major loop of the current in a pole of a generator circuit-breaker during the transient period following the initiation of current during a making operation

Note 1 to entry: The peak value may differ from one pole to another and from one operation to another as it depends on the instant of current initiation relative to the wave of the applied voltage.

Note 2 to entry: Where, for a polyphase circuit, a single value of (peak) making current is referred to, this is, unless otherwise stated, the highest value in any phase.

Note 3 to entry: See Figure 1 *a*.

3.7.109

prospective breaking current (for a pole of a switching device)
prospective current evaluated at the instant corresponding to the initiation of the arc during breaking process

3.7.110

breaking current (of a switching device or a fuse)
current in a pole of a switching device or in a fuse at the instant of initiation of the arc during a breaking process

[SOURCE: IEC 60050-441:1984, 441-17-07]

3.7.111

making current (of a switching device or a fuse)
value of prospective making current that a switching device is capable of making at a stated voltage under prescribed conditions of use and behaviour

Note 1 to entry: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant specifications.

[SOURCE: IEC 60050-441:1984, 441-17-09, modified – replacement of "capacity" by "current"]

3.7.112

short-circuit making current
making current for which the prescribed conditions include a short circuit at the terminals of the switching device

Note 1 to entry: See Figure 1 *a*.

[SOURCE: IEC 60050-441:1984, 441-17-10, modified – replacement of "capacity" by "current"]

3.7.113

short-circuit breaking current
breaking current for which the prescribed conditions include a short circuit at the terminals of the switching device

Note 1 to entry: See Figure 1 *b*.

[SOURCE: IEC 60050-441:1984, 441-17-11, modified – replacement of "capacity" by "current"]

3.7.114

short-time withstand current
current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behaviour

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

3.7.115

peak withstand current
value of peak current that a circuit or a switching device in the closed position can withstand under prescribed conditions of use and behaviour

[SOURCE: IEC 60050-441:1984, 441-17-18]

3.7.116

applied voltage (for a switching device)

voltage which exists across the terminals of a pole of a switching device just before the making of the current

[SOURCE: IEC 60050-441:1984, 441-17-24]

3.7.117

recovery voltage

voltage which appears across the terminals of a pole of a switching device or a fuse after the breaking of the current

Note 1 to entry: This voltage may be considered in two successive intervals of time, one during which a transient voltage exists, followed by a second one during which the power frequency or the steady-state recovery voltage alone exists.

[SOURCE: IEC 60050-441:1984, 441-17-25]

3.7.118

transient recovery voltage

TRV

recovery voltage during the time in which it has a significant transient character

Note 1 to entry: The transient recovery voltage may be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit and the switching device. It includes the voltage shift of the neutral of a polyphase circuit.

Note 2 to entry: The transient recovery voltages in three-phase circuits is, unless otherwise stated, that across the first-pole-to-clear, because this voltage is generally higher than that which appears across each of the other two poles.

[SOURCE: IEC 60050-441:1984, 441-17-26]

3.7.119

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.

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

3.7.120

power frequency recovery voltage

recovery voltage after the transient voltage phenomena have subsided

[SOURCE: IEC 60050-441:1984, 441-17-27]

3.7.121

peak arc voltage (of a mechanical switching device)

maximum instantaneous value of voltage which under prescribed conditions appears across the terminals of a pole of a switching device during the arcing time

[SOURCE: IEC 60050-441:1984, 441-17-30]

3.7.122

clearance

distance between two conductive parts along a string stretched the shortest way between these conductive parts

[SOURCE: IEC 60050-441:1984, 441-17-31]

3.7.123

clearance between poles

clearance between any conductive parts of adjacent poles

[SOURCE: IEC 60050-441:1984, 441-17-32]

3.7.124

clearance to earth

clearance between any conductive parts and any parts which are earthed or intended to be earthed

[SOURCE: IEC 60050-441:1984, 441-17-33]

3.7.125

clearance between open contacts

total clearance between the contacts, or any conductive parts connected thereto, of a pole of a mechanical switching device in the open position

[SOURCE: IEC 60050-441:1984, 441-17-34]

3.7.126

opening time

opening time is the interval of time between the instant of energising the opening release, the generator circuit-breaker being in the closed position, and the instant when the arcing contacts have separated in all poles

Note 1 to entry: The opening time may vary with the breaking current.

Note 2 to entry: For generator circuit-breakers with more than one interrupting unit per pole, the instant when the arcing contacts have separated in all poles is determined as the instant of contact separation in the first unit of the last pole.

Note 3 to entry: The opening time includes the operating time of any auxiliary equipment necessary to open the generator circuit-breaker and forming an integral part of the generator circuit-breaker.

Note 4 to entry: See Figure 1 *j*.

3.7.127

arcing time (of a pole)

interval of time between the instant of the first initiation of an arc and the instant of final arc extinction

Note 1 to entry: See Figure 1 *k*.

[SOURCE: IEC 60050-441:1984, 441-17-38, modified – deletion of the words "in all poles" at the end of the definition]

3.7.128

break-time

maximum interval of time between the energizing of the trip circuit at rated control voltage and rated fluid pressure of the operating mechanism and the end of the arcing time

Note 1 to entry: See Figure 1 *l*.

[SOURCE: IEC 60050-441:1984, 441-17-39, modified – the entire definition has been rephrased]

3.7.129

closing time

interval of time between energising the closing circuit, the generator circuit-breaker being in the open position, and the instant when the contacts touch in all poles

Note 1 to entry: The closing time includes the operating time of any auxiliary equipment necessary to close the generator circuit-breaker and forming an integral part of the generator circuit-breaker.

3.7.130

make-time

interval of time between energising the closing circuit, the generator circuit-breaker being in the open position, and the instant when the current begins to flow in the first pole

Note 1 to entry: The make time includes the operating time of any auxiliary equipment necessary to close the generator circuit-breaker and forming an integral part of the generator circuit-breaker.

Note 2 to entry: The make time may vary, e.g. due to the variation of the pre-arcing time.

Note 3 to entry: See Figure 1 *m*.

[SOURCE: IEC 60050-441:1984, 441-17-40, modified – the entire definition has been rephrased]

3.7.131

pre-arcing time

interval of time between the initiation of current flow in the first pole during a closing operation and the instant when the contacts touch in all poles for three-phase conditions and the instant when the contacts touch in the arcing pole for single-phase conditions

Note 1 to entry: The pre-arcing time depends on the instantaneous value of the applied voltage during a specific closing operation and therefore may vary considerably.

3.7.132

close-open time

interval of time between the instant when the contacts touch in the first pole during a closing operation and the instant when the arcing contacts have separated in all poles during the subsequent opening operation

Note 1 to entry: Unless otherwise stated, it is assumed that the opening release incorporated in the generator circuit-breaker is energised at the instant when the contacts touch in the first pole during closing. This represents the minimum close-open time.

[SOURCE: IEC 60050-441:1984, 441-17-42, modified – addition of a new note]

3.7.133

make-break time

interval of time between the initiation of current flow in the first pole during a closing operation and the end of the arcing time during the subsequent opening operation

Note 1 to entry: Unless otherwise stated, it is assumed that the opening release of the generator circuit-breaker is energised one half-cycle after current begins to flow in the main circuit during making. Here it is noted that the use of relays with shorter operating time can subject the circuit-breaker to higher asymmetrical currents.

Note 2 to entry: The make-break time can vary due to the variation of the pre-arcing time.

3.7.134

minimum trip signal duration

minimum time the auxiliary power is applied to the opening release to ensure complete opening of the generator circuit-breaker

3.7.135

minimum close signal duration

minimum time the auxiliary power is applied to the closing device to ensure complete closing of the generator circuit-breaker

3.7.136

normal current

current in r.m.s. amperes at power frequency that a generator circuit-breaker is capable of carrying continuously under specified conditions of use and behaviour without exceeding any of its designated limitations

3.7.137

first-pole-to-clear factor

<three-phase system> when interrupting any symmetrical three-phase current the first-pole-to-clear factor is the ratio of the power frequency voltage across the first interrupting pole before current interruption in the other poles, to the power frequency voltage occurring across the pole or the poles after interruption in all three poles

3.7.138

amplitude factor

ratio between the maximum excursion of the transient recovery voltage to the crest value of the power frequency recovery voltage

3.7.139

insulation level

for a generator circuit-breaker, a characteristic defined by two values indicating the insulation withstand voltages

[SOURCE: IEC 60050-604:1987, 604-03-47, modified – replacement of "particular item of equipment" by "generator circuit-breaker" and removal of "one or"]

3.7.140

power frequency withstand voltage

r.m.s. value of sinusoidal power frequency voltage that the generator circuit-breaker can withstand during tests made under specified conditions and for a specified time

[SOURCE: IEC 60050-604:1987, 604-03-40, modified – replacement of "equipment" by "generator circuit-breaker"]

3.7.141

impulse withstand voltage

peak value of the standard impulse voltage wave which the insulation of the generator circuit-breaker withstands under specified test conditions

3.7.142

minimum functional pressure for operation

pressure, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa, which may be expressed in relative or absolute terms, at which and above which rated characteristics of a circuit-breaker are maintained and at which a replenishment of the operating device becomes necessary

Note 1 to entry: This pressure is often designated as interlocking pressure (refer to 3.6.5.6 of IEC 62271-1:2007).

3.7.143

minimum functional pressure for interruption and insulation

pressure for interruption and for insulation, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa, which may be expressed in relative or absolute terms, at which and above which rated characteristics of a generator circuit-breaker are maintained and at which a replenishment of the interrupting and/or insulating fluid becomes necessary

Note 1 to entry: See also 3.6.5.5 of IEC 62271-1:2007.

Note 2 to entry: For generator circuit-breakers with a sealed pressure system (also termed sealed-for-life), the minimum functional pressure for interruption is the one at which the rated characteristics of the generator circuit-breaker are maintained taking into account the pressure drop at the end of the expected operating life.

3.7.144

degree of asymmetry (of a current at any time)

ratio (expressed as a percentage) of the d.c. component to the peak value of the a.c. component determined from the envelope of the current wave at that time

Note 1 to entry: This value is 100 % when the d.c. component equals the peak value of the a.c. component.

3.7.145

generator-source short-circuit current

short-circuit current when the source of the short-circuit current is entirely from a generator through no transformation

3.7.146

system-source short-circuit current

short-circuit current when the source of the short-circuit current is from the power system through at least one transformation

3.7.147

intermediate level of asymmetry

when in a three-phase system the short-circuit current is initiated simultaneously in all phases and maximum asymmetry is obtained in one of the phases, the intermediate asymmetry is the level of asymmetry in the other two phases having an intermediate (reduced) level of asymmetry

Note 1 to entry: See Figure 6.

3.7.148

earliest possible interruption in a phase with intermediate level of asymmetry after a major loop

the interruption with the shortest time (t_1) from fault current initiation to the first current zero after a major loop in the phase with intermediate level of asymmetry, taking into account:

- the minimum relay time (0,5 cycle of power frequency);
- the minimum opening time;
- the minimum arcing time;
- and that the subsequent current zero crossing of the prospective three-phase current occurs in the phase with maximum level of asymmetry after a major loop

Note 1 to entry: This definition is to be used only for the determination of the test parameters during asymmetrical short-circuit breaking tests. (TD2 – System-source fault)

Note 2 to entry: See Figure 7.

3.7.149

earliest possible interruption in a phase with intermediate level of asymmetry after a minor loop

the interruption with the shortest time (t_2) from fault current initiation to the first current zero after a minor loop in the phase with intermediate level of asymmetry, taking into account:

- the minimum relay time (0,5 cycle of power frequency);
- the minimum opening time;
- the minimum arcing time;
- and that the subsequent current zero crossing of the prospective three-phase current occurs in the other phase with intermediate level of asymmetry after a major loop

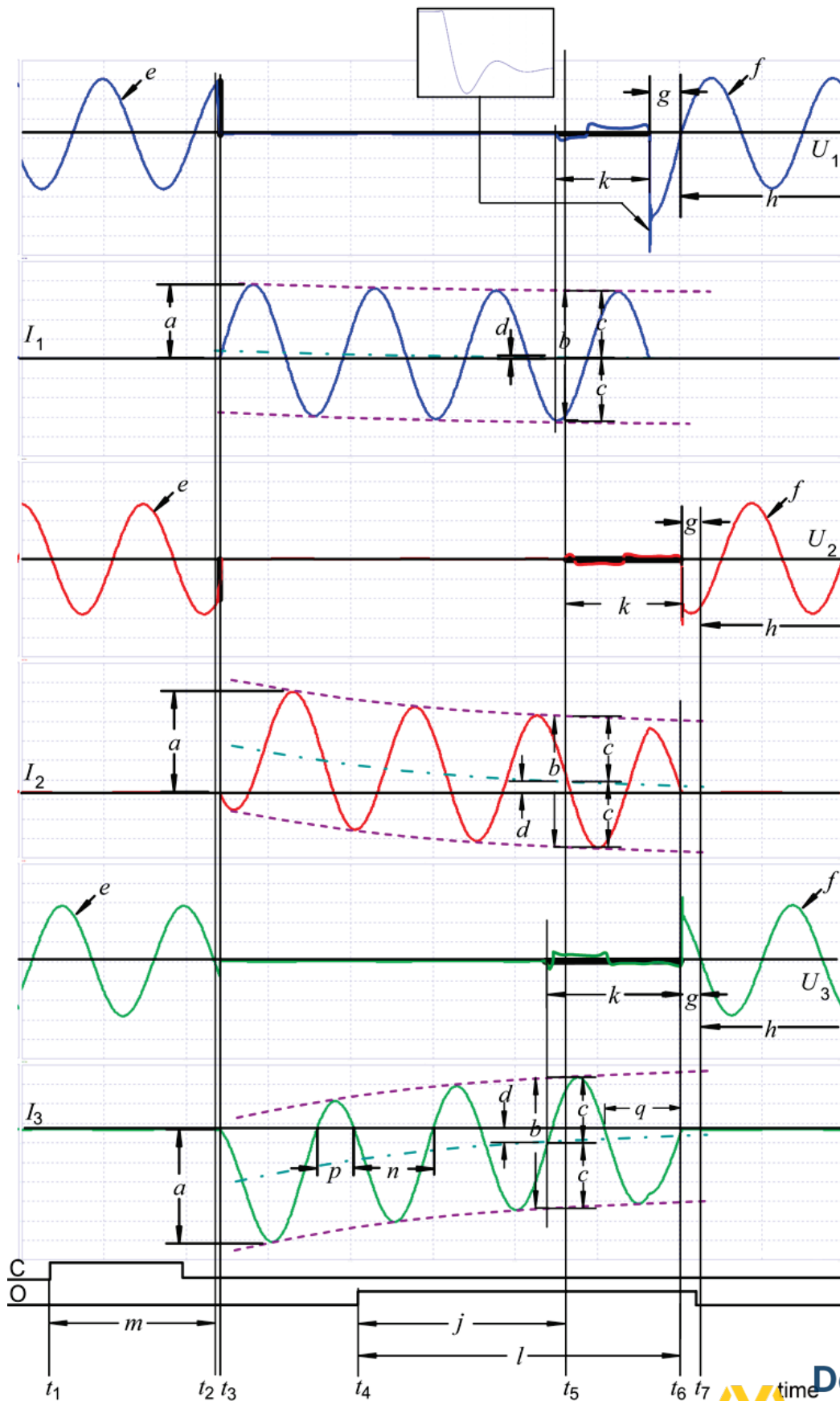
Note 1 to entry: This definition is to be used only for the determination of the test parameters during asymmetrical short-circuit breaking tests. (TD2 – System-source fault)

Note 2 to entry: See Figure 8.

3.7.150

minimum arcing time (of a switching device)

shortest interval of time between the instant of the initiation of an arc and the instant of arc extinction



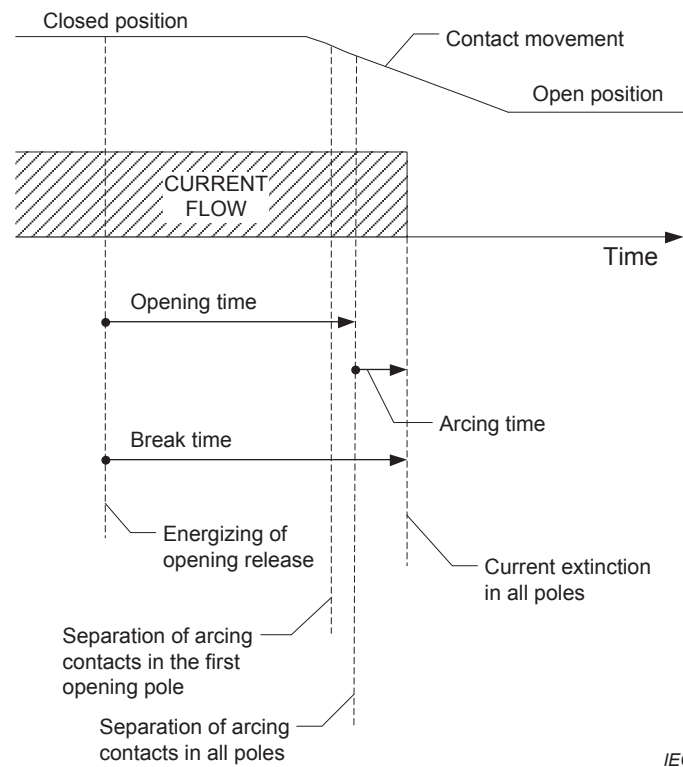
U_1	voltage across the terminals of the first-pole-to-clear	a	(peak) making current
I_1	current in the first-pole-to-clear	b	peak-to-peak value of the a.c. component
U_2, U_3	voltage across the terminals of the two other poles	c	peak value of the a.c. component
I_2, I_3	current in the two other poles	d	d.c. component
C	closing command, e.g. voltage across the terminals of the closing circuit	e	applied voltage
O	opening command, e.g. voltage across the terminals of the opening release	f	recovery voltage
t_1	the instant of initiation of the closing operation	g	transient recovery voltage
t_2	the instant when the current begins to flow in the main circuit	h	power frequency recovery voltage
t_3	the instant when the current is established in all poles	j	opening time
t_4	the instant of energizing the opening release	k	arcing time
t_5	the instant when the arcing contacts have separated (or instant of initiation of the arc) in all poles	l	break time
t_6	the instant of final arc extinction in all poles	m	make time
t_7	the instant when the transient voltage phenomena have subsided in the last-pole-to-clear	n	major loop
NOTE 1 Indicators i and o are not used.		p	minor loop
NOTE 2 The rms value of the a.c. component of the breaking current is $c/\sqrt{2}$.		q	major extended loop

Figure 1 – Typical oscillogram of a three-phase short-circuit make-break cycle

Notes to the following Figures 2 to 5:

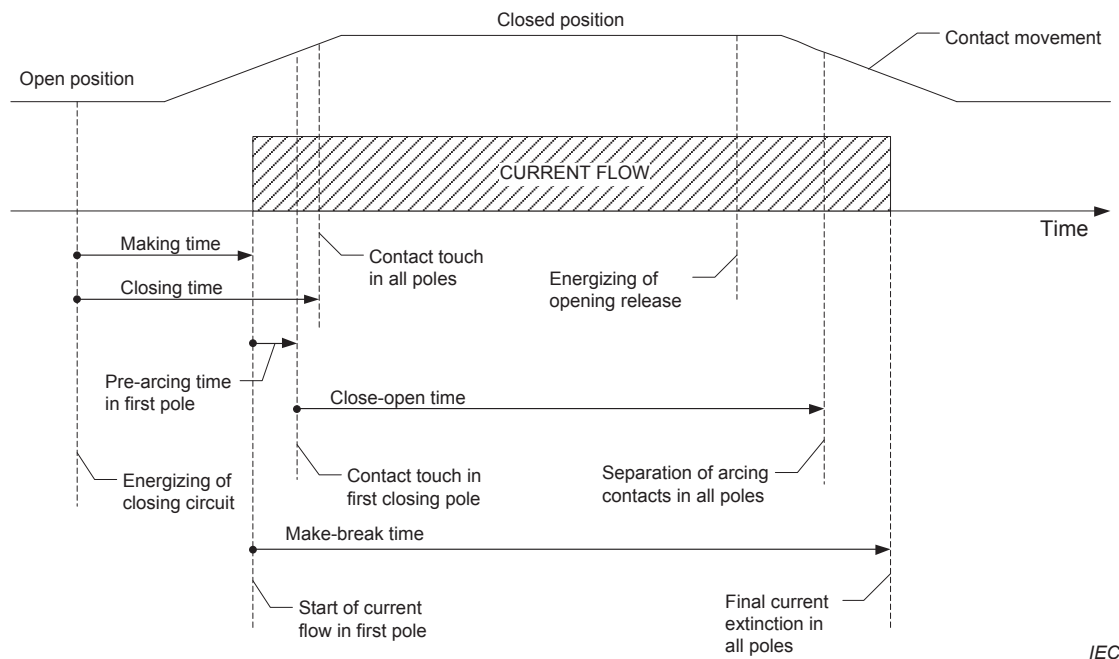
NOTE 1 In practice, there will be a time spread between the travel of the contacts of the three poles. For clarity the travel of the contacts in the figures is indicated with a single line for all three poles.

NOTE 2 In practice, there will be a time spread between both the start and end of current flow in the three poles. For clarity, both the start and end of current flow in the figures is indicated with a single line for all three poles.



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Figure 2 – Generator circuit-breaker without resistors – Opening operation



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Figure 3 – Generator circuit-breaker without resistors – Close-open cycle

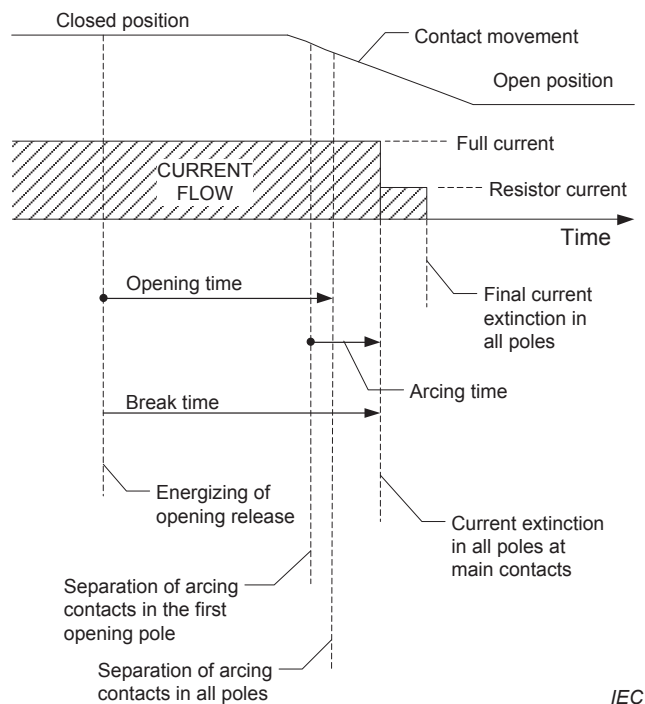


Figure 4 – Generator circuit-breaker with opening resistors – Opening operation

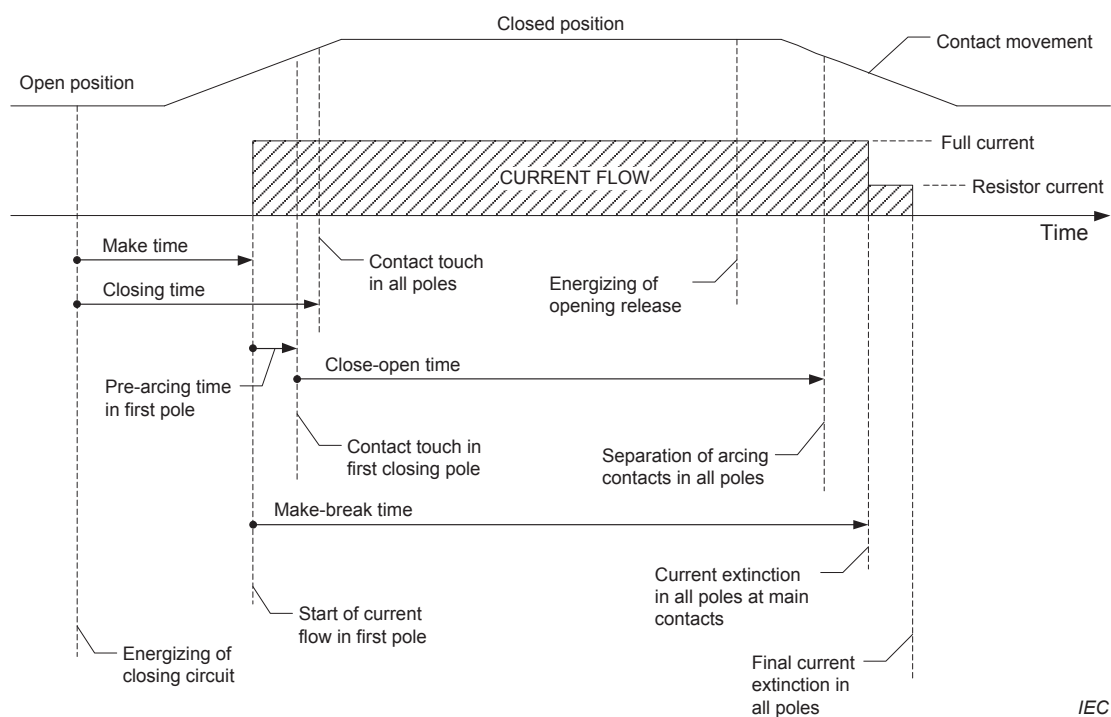


Figure 5 – Generator circuit-breaker with opening resistors – Close-open cycle

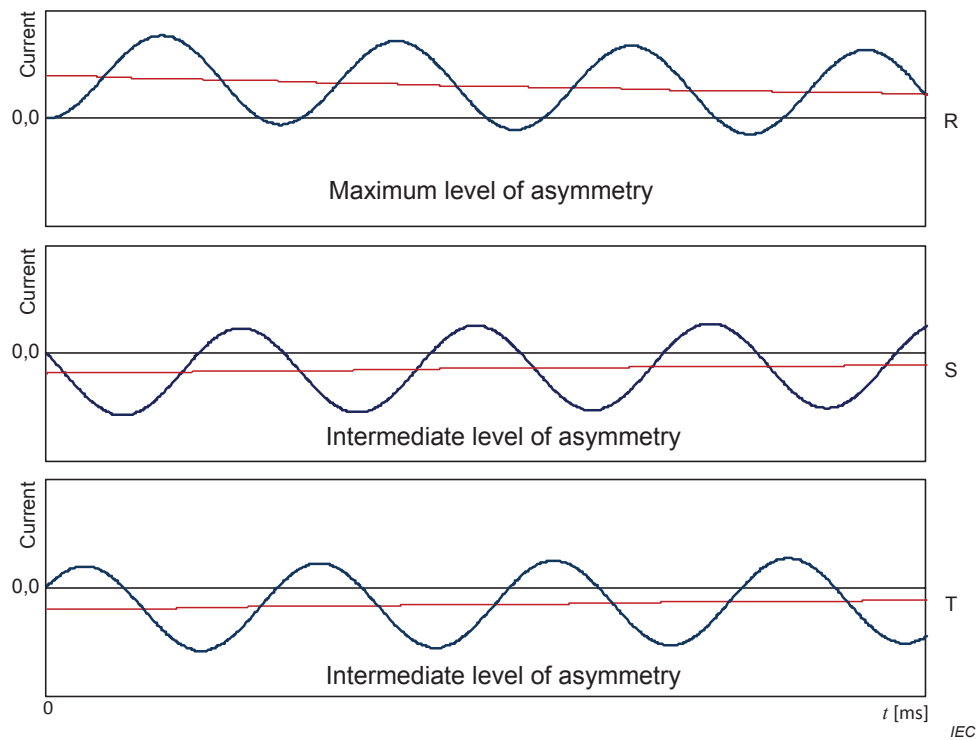


Figure 6 – Example of a three-phase asymmetrical current

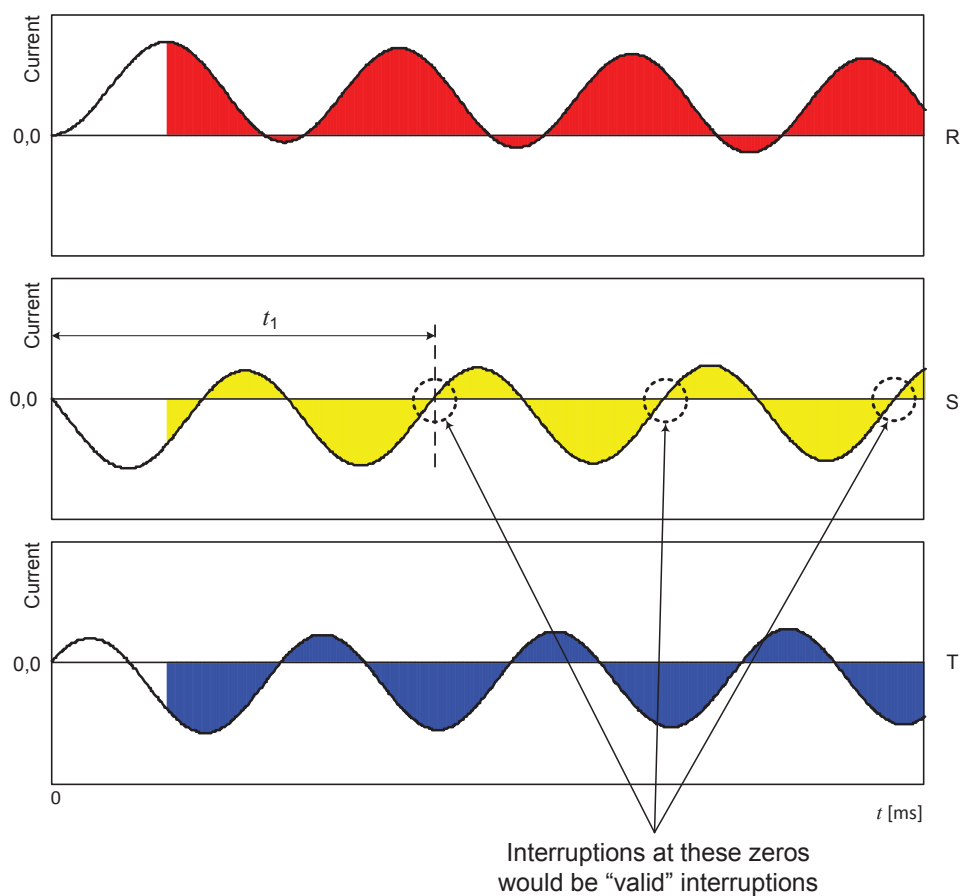
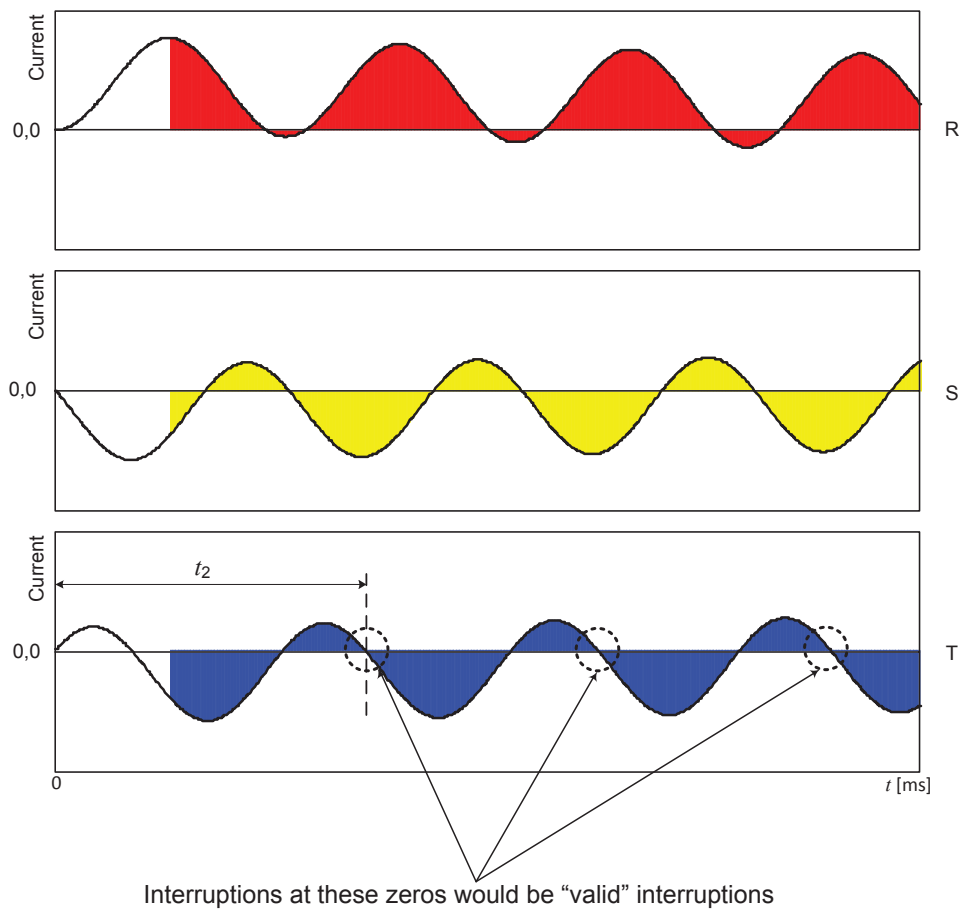


Figure 7 – Examples of possible valid interruptions in a phase with intermediate level of asymmetry after a major loop and a corresponding time t_1



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Figure 8 – Examples of possible valid interruptions in a phase with intermediate level of asymmetry after a minor loop and a corresponding time t_2

3.8 Index of definitions

A

"a" contact, make contact	3.5.111
Air-blast circuit-breaker	3.4.110
Air circuit-breaker	3.4.105
Alternative operating mechanism	3.5.123
Amplitude factor	3.7.138
Anti-pumping device	3.6.111
Applied voltage (for a switching device)	3.7.116
Arcing contact	3.5.107
Arcing time (of a pole)	3.7.127
Arc control device	3.5.114
Auxiliary circuit	3.5.104
Auxiliary contact	3.5.109
Auxiliary switch	3.5.110

B

"b" contact, break contact	3.5.112
----------------------------	---------

Break contact	3.5.112
Breaking current (of a switching device or a fuse)	3.7.110
Breaking operation	3.6.114
Breaking unit	3.5.118
Break-time	3.7.128

C

Circuit-breaker	3.4.103
Class G1 generator circuit-breaker	3.4.113
Class G2 generator circuit-breaker	3.4.114
Class M1 generator circuit-breaker	3.4.111
Class M2 generator circuit-breaker	3.4.112
Clearance	3.7.122
Clearance between open contacts	3.7.125
Clearance between poles	3.7.123
Clearance to earth	3.7.124
Closed position	3.6.107
Close-open operation (CO)	3.6.115
Close-open time	3.7.132
Closing operation (C)	3.6.104
Closing time	3.7.129
Connection (bolted or the equivalent)	3.5.116
Contact	3.5.105
Control circuit	3.5.103
Control contact	3.5.108

D

Degree of asymmetry (of a current at any time)	3.7.144
Disruptive discharge	3.1.112

E

Earliest possible interruption in a phase with intermediate level of asymmetry after a major loop	3.7.148
Earliest possible interruption in a phase with intermediate level of asymmetry after a minor loop	3.7.149
Effectively earthed neutral system	3.1.114
Enclosure	3.5.120
External insulation	3.1.109

F

First-pole-to-clear factor (in a three-phase system)	3.7.137
--	---------

G

Gas-blast circuit-breaker	3.4.108
Generator circuit-breaker	3.4.104
Generator circuit-breaker class G1	3.4.113
Generator circuit-breaker class G2	3.4.114
Generator circuit-breaker class M1	3.4.111
Generator circuit-breaker class M2	3.4.112

Generator-source short-circuit current		3.7.145
	I	
Impulse withstand voltage		3.7.141
Insulation level		3.7.139
Interlocking device		3.6.112
Intermediate level of asymmetry		3.7.147
Isolated-phase bus		3.1.118
	L	
Loop		3.1.107
	M	
Main circuit		3.5.102
Main contact		3.5.106
Make-break operation		3.6.116
Make-break time		3.7.133
Make contact		3.5.111
Make-time		3.7.130
Making current (of a switching device or a fuse)		3.7.111
(Peak) Making current		3.7.108
Making operation		3.6.113
Making unit		3.5.118
Maximum prospective peak current (of an a.c. circuit)		3.7.106
Mechanical switching device		3.4.102
Minimum arcing time (of a switching device)		3.7.150
Minimum close signal duration		3.7.135
Minimum functional pressure for interruption and insulation		3.7.143
Minimum functional pressure for operation		3.7.142
Minimum trip signal duration		3.7.134
Module		3.5.119
Moment of inertia		3.1.103
	N	
Non-effectively earthed neutral system		3.1.115
Non-self-restoring insulation		3.1.111
Non-sustained disruptive discharge (NSDD)		3.1.113
Normal current		3.7.136
NSDD		3.1.113
	O	
Oil circuit-breaker		3.4.106
Opening operation (O)		3.6.105
Opening time		3.7.126
Open position		3.6.108
Operating cycle		3.6.102
Operating mechanism		3.5.121
Operating sequence		3.6.103
Operation		3.6.101



Out-of-phase (as prefix to a characteristic quantity)	3.1.105
Out-of-phase conditions	3.1.104
P	
Peak arc voltage (of a mechanical switching device)	3.7.121
Peak current	3.7.104
(Peak) making current	3.7.108
Peak withstand current	3.7.115
Pole	3.5.101
Position indicating device	3.5.115
Power factor (of a circuit)	3.1.108
Power frequency recovery voltage	3.7.120
Power frequency withstand voltage	3.7.140
Power kinematic chain	3.5.122
Pre-arcing time	3.7.131
Prospective breaking current (for a pole of a circuit-breaker)	3.7.109
Prospective current (of a circuit and with respect to a switching device or a fuse)	3.7.102
Prospective making current (for a pole of a switching device)	3.7.107
Prospective peak current	3.7.103
Prospective symmetrical current (of an a.c. circuit)	3.7.105
Prospective transient recovery voltage (of a circuit)	3.7.119
R	
Rated value	3.7.101
Recovery voltage	3.7.117
Re-ignition (of an a.c. mechanical switching device)	3.1.116
Release	3.5.113
Restrike (of an a.c. mechanical switching device)	3.1.117
S	
Self-restoring insulation	3.1.110
Short-circuit current	3.1.102
Short-circuit breaking current	3.7.113
Short-circuit making current	3.7.112
Short-time withstand current	3.7.114
Shunt release	3.6.110
Stored energy operation	3.6.106
Switchgear and controlgear	3.1.101
Switching device	3.4.101
System-source short-circuit current	3.7.146
T	
Terminal	3.5.117
Transient recovery voltage (TRV)	3.7.118
Trip-free mechanical switching device	3.6.109
TRV	3.7.118
U	
(Making or breaking) Unit	3.5.118



Unit test		3.1.106
	V	
Vacuum circuit-breaker		3.4.107

4 Ratings

Clause 4 of IEC 62271-1:2007 is replaced by the following:

The ratings and required capabilities of a generator circuit-breaker are the designated limits of operating characteristics based on definite conditions and shall include the following items, where applicable:

- a) rated voltage;
- b) rated insulation level;
- c) rated frequency;
- d) rated normal current;
- e) rated short-time withstand current;
- f) rated peak withstand current;
- g) rated duration of short-circuit;
- h) rated supply voltage of closing and opening devices and of auxiliary circuits;
- i) rated supply frequency of closing and opening devices and of auxiliary circuits;
- j) rated pressures of compressed gas supply and/or of hydraulic supply for operation, interruption and insulation, as applicable;
- k) rated system-source short-circuit breaking current;
- l) rated short-circuit making current;
- m) rated load making and breaking current;
- n) rated transient recovery voltage (TRV);
- o) rated operating sequence;
- p) rated time quantities.

The following characteristics are not mandatory but shall be given on request if assigned.

- q) rated out-of-phase making and breaking current;
- r) rated generator-source short-circuit breaking current.

4.1 Rated voltage U_r

Subclause 4.1 of IEC 62271-1:2007 is replaced by the following:

The rated voltage of a generator circuit-breaker is the highest r.m.s. voltage for which the generator circuit-breaker is designed and is the upper limit for operation.

NOTE 1 The rated voltage can also be referred to as rated maximum voltage.

NOTE 2 The rated voltage is equal to the maximum operating voltage of the generator (usually equal to 1,05 times the rated voltage of the generator) to which the generator circuit-breaker is applied.

4.2 Rated insulation level

NOTE The rated insulation level can also be referred to as rated dielectric strength.

Subclause 4.2 of IEC 62271-1:2007 is replaced by the following:

The rated insulation level of a generator circuit-breaker is its voltage withstand capability with specified magnitudes and waveshapes.

4.2.101 Dielectric strength

Dielectric strength shall conform to the performance requirements of this standard. Requirements for the rated dielectric strength of the generator circuit-breakers are given in Table 1.

Table 1 – Rated insulation levels for a.c. generator circuit-breakers

(1)	Insulation withstand voltages	
	(2)	(3)
Rated voltage U_r kV (r.m.s. value)	Rated power-frequency withstand voltage U_d kV (r.m.s. value)	Rated lightning impulse withstand voltage U_p kV (peak value)
$U_r \leq 7,2$	20	60
$7,2 < U_r \leq 12$	28	75
$12 < U_r \leq 15$	38	95
$15 < U_r \leq 17,5$	50	110
$17,5 < U_r \leq 27$	60	125
$27 < U_r \leq 38$	80	150

These values are applicable for indoor and outdoor generator circuit-breakers.

4.2.102 Rated power frequency withstand voltage U_d

The rated power frequency withstand voltage is the voltage that a new generator circuit-breaker shall be capable of withstanding for 1 min (see Column (2) of Table 1 and 6.2.6.1).

4.2.103 Rated lightning impulse withstand voltage U_p

The rated lightning impulse withstand voltage is the peak value of a standard $1,2 \times 50 \mu s$ impulse voltage wave that a new generator circuit-breaker shall be capable of withstanding (see Column (3) of Table 1 and 6.2.6.2).

4.3 Rated frequency f_r

Subclause 4.3 of IEC 62271-1:2007 is applicable with the following modification:

The standard values for the rated frequency of generator circuit-breakers are 50 Hz and 60 Hz.

If rated for both 50 Hz and 60 Hz, the nameplate may be marked 50/60 Hz.

Applications at other frequencies require special considerations.

NOTE The rated frequency can also be referred to as rated power frequency.

4.4 Rated normal current I_r and temperature rise

4.4.1 Rated normal current I_r

Subclause 4.4.1 of IEC 62271-1:2007 is applicable with the following addition.

Values from the R 10 series are preferred values only. Manufacturers and users are free to choose any other values.

NOTE The rated normal current can also be referred to as rated continuous current.

4.4.2 Temperature rise

Subclause 4.4.2 of IEC 62271-1:2007 is applicable with the following addition:

Generator circuit-breaker parts handled by the operator in the normal course of work duties shall have a maximum temperature no greater than 50 °C.

4.4.3 Particular points of Table 3 of IEC 62271-1:2007

Subclause 4.4.3 of IEC 62271-1:2007 is applicable.

4.4.101 Emergency current ratings during loss of cooling

The operating considerations for generator circuit-breakers require that emergency ratings are established to enable the circuit-breaker to remain in service following loss of normally required cooling systems.

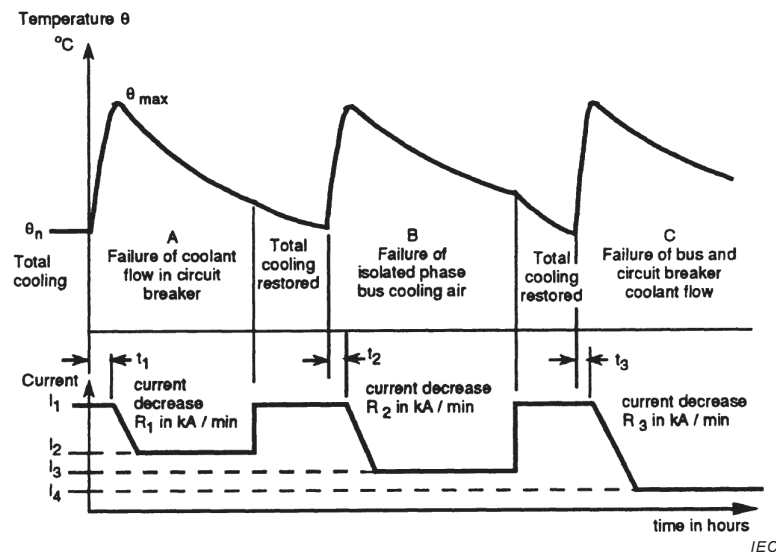
The following provisions shall be observed:

- a) It is possible to operate the generator circuit-breaker for limited time periods with circuit-breaker parts at a higher total temperature than the limits specified for the normal current rating;
- b) The difference between the emergency temperature limits and the normal operating temperatures provide a definite allowable time period during which full load may be carried before the reduction in load current shall be accomplished;
- c) The generator circuit-breaker may remain in service at a reduced load current, the value of which will depend on the type of emergency condition prevailing;
- d) Where the circuit-breaker normal current rating is affected by several independent systems (e.g., interrupting medium, cooling medium, forced air cooling of isolated phase bus, etc.), the effect of losing each system individually and in combination should be established;
- e) In addition to a) through d), certain generating station designs (e.g., single generator output connected by two generator circuit-breakers to two unit step-up transformers) may also require special emergency operating conditions and ratings.

For each emergency condition the following parameters shall be given:

- t_e The time available at rated current before the load shall be reduced;
- R_e The rate at which the load current shall be reduced in kA/min;
- I_e The emergency current assigned to the generator circuit-breaker for operating under each emergency condition for an unlimited period of time.

Figure 9 illustrates typical emergency conditions in which the loss of two cooling systems, that of the generator circuit-breaker and that of the bus, have been studied separately and simultaneously.



Key

- I_1 is the rated current with all cooling systems in operation
- I_2 is the allowable load current if failure (A) of coolant in circuit-breaker occurs
- I_3 is the allowable load current if failure (B) of isolated phase bus cooling air occurs
- I_4 is the allowable load current if failure (C) of isolated bus and circuit-breaker coolant flow occurs
- $\theta_{\max}$ is the allowable hottest spot total temperature in °C
- θ_n is the hottest spot total temperature at rated continuous current
- t_1, t_2, t_3 are the allowable times without a reduction in rated continuous current and without exceeding $\theta_{\max}$

Figure 9 – Effect of various cooling failures and subsequent load reductions on generator circuit-breaker temperature

The following are the parameters that are required for correct operation under each type of emergency condition and for which values shall be determined by the manufacturer:

- t_1, t_2, t_3 are the times available at rated current before the load shall be reduced.
- R_1, R_2, R_3 are the rates at which the load current shall be reduced in kA/min.
- I_2, I_3, I_4 are the emergency currents assigned to the generator circuit-breaker for operating under each emergency condition for an unlimited period of time.

4.5 Rated short-time withstand current I_k

Subclause 4.5 of IEC 62271-1:2007 is applicable.

4.6 Rated peak withstand current I_p

Subclause 4.6 of IEC 62271-1:2007 is applicable with the following modification:

A d.c. time constant of 133 ms covers the majority of cases and corresponds to a rated peak withstand current equal to 2,74 times the rated short-time withstand current.

4.7 Rated duration of short circuit t_k

Subclause 4.7 of IEC 62271-1:2007 is applicable with the following change.

The minimum value of t_k shall be 1 s.

4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits U_a

4.8.1 General

Subclause 4.8.1 of IEC 62271-1:2007 is applicable with the following addition:

In general the supply voltage is measured at the control power terminals of the operating mechanism at the peak operating current.

4.8.2 Rated supply voltage U_a

Subclause 4.8.2 of IEC 62271-1:2007 is not applicable and is replaced by the following:

Preferred values of supply voltages are given in Table 2.

4.8.3 Tolerances

Subclause 4.8.3 of IEC 62271-1:2007 is not applicable and is replaced by the following:

Preferred ranges of the supply voltages are given in Table 2.