

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Appareillage à haute tension –
Partie 100: Disjoncteurs à courant alternatif**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2012 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.



IEC 62271-100

Edition 2.1 2012-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Appareillage à haute tension –
Partie 100: Disjoncteurs à courant alternatif**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

CV

ICS 29.130.10

ISBN 978-2-8322-0403-0

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	20
1 General.....	22
1.1 Scope.....	22
1.2 Normative references.....	23
2 Normal and special service conditions.....	24
3 Terms and definitions.....	24
3.1 General terms.....	24
3.2 Assemblies.....	28
3.3 Parts of assemblies.....	28
3.4 Switching devices.....	28
3.5 Parts of circuit-breakers.....	30
3.6 Operation.....	32
3.7 Characteristic quantities.....	35
3.8 Index of definitions.....	41
4 Ratings.....	45
4.1 Rated voltage (U_r).....	46
4.2 Rated insulation level.....	46
4.3 Rated frequency (f_r).....	47
4.4 Rated normal current (I_r) and temperature rise.....	48
4.5 Rated short-time withstand current (I_k).....	48
4.6 Rated peak withstand current (I_p).....	48
4.7 Rated duration of short circuit (t_k).....	48
4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a).....	48
4.9 Rated supply frequency of closing and opening devices and auxiliary circuits.....	48
4.10 Rated pressures of compressed gas supply for insulation, operation and/or interruption.....	48
4.101 Rated short-circuit breaking current (I_{SC}).....	49
4.101.1 AC component of the rated short-circuit breaking current.....	49
4.101.2 DC time constant of the rated short-circuit breaking current.....	49
4.102 Transient recovery voltage related to the rated short-circuit breaking current.....	50
4.102.1 Representation of TRV waves.....	50
4.102.2 Representation of TRV.....	51
4.102.3 Standard values of TRV related to the rated short-circuit breaking current.....	54
4.102.4 Standard values of ITRV.....	61
4.103 Rated short-circuit making current.....	61
4.104 Rated operating sequence.....	62
4.105 Characteristics for short-line faults.....	63
4.106 Rated out-of-phase making and breaking current.....	64
4.107 Rated capacitive switching currents.....	65
4.107.1 Rated line-charging breaking current.....	66
4.107.2 Rated cable-charging breaking current.....	66
4.107.3 Rated single capacitor bank breaking current.....	66
4.107.4 Rated back-to-back capacitor bank breaking current.....	67
4.107.5 Rated single capacitor bank inrush making current.....	67

4.108	Inductive load switching	67
4.109	Rated time quantities	67
4.109.1	Rated break-time	68
4.110	Number of mechanical operations	70
4.111	Classification of circuit-breakers as a function of electrical endurance	70
5	Design and construction	70
5.1	Requirements for liquids in circuit-breakers	70
5.2	Requirements for gases in circuit-breakers	70
5.3	Earthing of circuit-breakers	70
5.4	Auxiliary equipment	70
5.5	Dependent power closing	71
5.6	Stored energy closing	71
5.7	Independent manual operation	71
5.8	Operation of releases	72
5.8.101	Over-current release	72
5.8.101.1	Operating current	72
5.8.101.2	Operating time	72
5.8.101.3	Resetting current	72
5.8.102	Multiple releases	72
5.8.103	Operation limits of releases	72
5.8.104	Power consumption of releases	72
5.8.105	Integrated relays for self-tripping circuit-breakers	73
5.9	Low- and high-pressure interlocking devices	73
5.10	Nameplates	73
5.11	Interlocking devices	75
5.12	Position indication	75
5.13	Degrees of protection by enclosures	75
5.14	Creepage distances	75
5.15	Gas and vacuum tightness	75
5.16	Liquid tightness	75
5.17	Fire hazard (flammability)	75
5.18	Electromagnetic compatibility	75
5.19	X-ray emission	76
5.20	Corrosion	76
5.101	Requirements for simultaneity of poles during single closing and single opening operations	76
5.102	General requirement for operation	76
5.103	Pressure limits of fluids for operation	76
5.104	Vent outlets	77
6	Type tests	77
6.1	General	79
6.1.1	Grouping of tests	79
6.1.2	Information for identification of specimens	79
6.1.3	Information to be included in type test reports	79
6.1.101	Invalid tests	79
6.2	Dielectric tests	80
6.2.1	Ambient air conditions during tests	80
6.2.2	Wet test procedure	80
6.2.3	Condition of circuit-breaker during dielectric tests	80

6.2.4	Criteria to pass the test.....	80
6.2.5	Application of test voltage and test conditions.....	80
6.2.6	Tests of circuit-breakers of $U_r \leq 245$ kV	81
6.2.7	Tests of circuit-breakers of $U_r > 245$ kV	81
6.2.8	Artificial pollution tests.....	82
6.2.9	Partial discharge tests	82
6.2.10	Tests on auxiliary and control circuits	82
6.2.11	Voltage test as a condition check.....	82
6.3	Radio interference voltage (r.i.v.) tests	85
6.4	Measurement of the resistance of the main circuit	85
6.5	Temperature-rise tests.....	85
6.5.1	Conditions of the circuit-breaker to be tested.....	85
6.5.2	Arrangement of the equipment.....	85
6.5.3	Measurement of the temperature and the temperature rise	85
6.5.4	Ambient air temperature	85
6.5.5	Temperature-rise tests of the auxiliary and control equipment.....	85
6.5.6	Interpretation of the temperature-rise tests	85
6.6	Short-time withstand current and peak withstand current tests.....	85
6.6.1	Arrangement of the circuit-breaker and of the test circuit	86
6.6.2	Test current and duration.....	86
6.6.3	Behaviour of the circuit-breaker during test.....	86
6.6.4	Conditions of the circuit-breaker after test	86
6.7	Verification of the degree of protection	86
6.7.1	Verification of the IP coding	86
6.7.2	Mechanical impact test	86
6.8	Tightness tests	86
6.9	Electromagnetic compatibility (EMC) tests	87
6.9.3.1	Ripple on d.c. input power port immunity test.....	87
6.9.3.2	Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests	87
6.10	Additional tests on auxiliary and control circuits.....	87
6.10.1	General	87
6.10.2	Functional tests	87
6.10.3	Electrical continuity of earthed metallic parts test	87
6.10.4	Verification of the operational characteristics of auxiliary contacts	87
6.10.5	Environmental tests	87
6.101	Mechanical and environmental tests	88
6.101.1	Miscellaneous provisions for mechanical and environmental tests	88
6.101.1.1	Mechanical characteristics.....	88
6.101.1.2	Component tests.....	88
6.101.1.3	Characteristics and settings of the circuit-breaker to be recorded before and after the tests	89
6.101.1.4	Condition of the circuit-breaker during and after the tests	89
6.101.1.5	Condition of the auxiliary and control equipment during and after the tests	90
6.101.2	Mechanical operation test at ambient air temperature	90
6.101.2.1	General	90
6.101.2.2	Condition of the circuit-breaker before the test.....	90
6.101.2.3	Description of the test on class M1 circuit-breakers	91

6.101.2.4	Extended mechanical endurance tests on class M2 circuit-breakers for special service requirements	91
6.101.2.5	Acceptance criteria for the mechanical operation tests.....	92
6.101.3	Low and high temperature tests	92
6.101.3.1	General	92
6.101.3.2	Measurement of ambient air temperature	93
6.101.3.3	Low temperature test	93
6.101.3.4	High-temperature test	95
6.101.4	Humidity test.....	96
6.101.4.1	General	96
6.101.4.2	Test procedure	96
6.101.5	Test to prove the operation under severe ice conditions	97
6.101.6	Static terminal load test	97
6.101.6.1	General	97
6.101.6.2	Tests	98
6.102	Miscellaneous provisions for making and breaking tests	99
6.102.1	General	99
6.102.2	Number of test specimens	100
6.102.3	Arrangement of circuit-breaker for tests	101
6.102.3.1	General	101
6.102.3.2	Common enclosure type	102
6.102.3.3	Multi-enclosure type	102
6.102.3.4	Self-tripping circuit-breakers	102
6.102.4	General considerations concerning testing methods	102
6.102.4.1	Single-phase testing of a single pole of a three-pole circuit-breaker	102
6.102.4.2	Unit testing	103
6.102.4.2.1	Identical nature of the units	105
6.102.4.2.2	Voltage distribution.....	105
6.102.4.2.3	Requirements for unit testing.....	106
6.102.4.3	Multi-part testing.....	106
6.102.5	Synthetic tests	106
6.102.6	No-load operations before tests	107
6.102.7	Alternative operating mechanisms	107
6.102.8	Behaviour of circuit-breaker during tests	108
6.102.9	Condition of circuit-breaker after tests	108
6.102.9.1	General	108
6.102.9.2	Condition after a short-circuit test-duty	109
6.102.9.3	Condition after a short-circuit test series.....	109
6.102.9.4	Condition after a capacitive current switching test series	110
6.102.9.5	Reconditioning after a short-circuit test-duty and other test series.....	111
6.102.10	Demonstration of arcing times	111
6.102.10.1	Three-phase tests	111
6.102.10.1.1	Test-duty T10, T30, T60, T100s, T100s(b), OP1 and OP2	111
6.102.10.1.2	Test-duty T100a	112
6.102.10.2	Single-phase tests in substitution for three-phase conditions.....	113
6.102.10.2.1	Non-effectively earthed neutral systems	113
6.102.10.2.1.1	Test-duties T10, T30, T60, T100s and T100s(b), OP1 and OP2	113
6.102.10.2.1.2	Test-duty T100a	114

6.102.10.2.2	Effectively earthed neutral systems including short-line fault tests	125
6.102.10.2.2.1	Test-duties T10, T30, T60, T100s and T100s(b), OP1 and OP2, L ₉₀ , L ₇₅ and L ₆₀	125
6.102.10.2.2.2	Test-duty T100a	125
6.102.10.2.3	Modified procedure in cases where the circuit-breaker failed to interrupt during a test with a medium arcing time	125
6.102.10.2.3.1	Breaking test with symmetrical current	125
6.102.10.2.3.2	Breaking test with asymmetrical current	126
6.102.10.2.4	Tests combining the conditions for effectively and non-effectively earthed neutral systems	126
6.102.10.2.5	Splitting of test-duties in test series taking into account the associated TRV for each pole-to-clear	126
6.103	Test circuits for short-circuit making and breaking tests	127
6.103.1	Power factor	127
6.103.2	Frequency	127
6.103.3	Earthing of test circuit	127
6.103.4	Connection of test circuit to circuit-breaker	129
6.104	Short-circuit test quantities	129
6.104.1	Applied voltage before short-circuit making tests	129
6.104.2	Short-circuit making current	129
6.104.2.1	General	129
6.104.2.2	Test procedure	130
6.104.2.2.1	Three-phase tests	130
6.104.2.2.2	Single-phase tests	130
6.104.3	Short-circuit breaking current	131
6.104.4	DC component of short-circuit breaking current	131
6.104.5	Transient recovery voltage (TRV) for short-circuit breaking tests	132
6.104.5.1	General	132
6.104.5.2	Test-duties T100s and T100a	137
6.104.5.3	Test duty T60	138
6.104.5.4	Test duty T30	138
6.104.5.5	Test duty T10	138
6.104.5.6	Test-duties OP1 and OP2	139
6.104.6	Measurement of transient recovery voltage during test	139
6.104.7	Power frequency recovery voltage	147
6.105	Short-circuit test procedure	147
6.105.1	Time interval between tests	147
6.105.2	Application of auxiliary power to the opening release – Breaking tests	148
6.105.3	Application of auxiliary power to the opening release – Make-break tests	148
6.105.4	Latching on short-circuit	148
6.106	Basic short-circuit test-duties	149
6.106.1	Test-duty T10	149
6.106.2	Test-duty T30	149
6.106.3	Test-duty T60	149
6.106.4	Test-duty T100s	149
6.106.4.1	Time constant of the d.c. component of the test circuit equal to the specified value	150

6.106.4.2	Time constant of the d.c. component of the test circuit less than the specified value	150
6.106.4.3	Time constant of the d.c. component of the test circuit greater than the specified value	151
6.106.4.4	Significant decay of the a.c. component of the test circuit	151
6.106.5	Test-duty T100a	153
6.106.6	Asymmetry criteria	153
6.106.6.1	Three-phase tests	154
6.106.6.1.1	Test current amplitude and last current loop duration	154
6.106.6.1.2	Percentage of d.c. component at current zero	154
6.106.6.2	Single-phase tests	155
6.106.6.2.1	Test current amplitude and last current loop duration	155
6.106.6.2.2	Percentage of the d.c. component at current zero	155
6.106.6.3	Adjustment measures	155
6.107	Critical current tests	156
6.107.1	Applicability	156
6.107.2	Test current	156
6.107.3	Critical current test-duty	156
6.108	Single-phase and double-earth fault tests	156
6.108.1	Applicability	156
6.108.2	Test current and recovery voltage	157
6.108.3	Test-duty	157
6.109	Short-line fault tests	158
6.109.1	Applicability	158
6.109.2	Test current	158
6.109.3	Test circuit	159
6.109.4	Test-duties	161
6.109.5	Short-line fault tests with a test supply of limited power	162
6.110	Out-of-phase making and breaking tests	162
6.110.1	Test circuit	162
6.110.2	Test voltage	163
6.110.3	Test-duties	163
6.111	Capacitive current switching tests	164
6.111.1	Applicability	164
6.111.2	General	164
6.111.3	Characteristics of supply circuits	165
6.111.4	Earthing of the supply circuit	165
6.111.5	Characteristics of the capacitive circuit to be switched	166
6.111.5.1	Line-charging and cable-charging current switching tests	166
6.111.5.2	Capacitor bank current switching tests	167
6.111.6	Waveform of the current	167
6.111.7	Test voltage	167
6.111.8	Test current	168
6.111.9	Test-duties	168
6.111.9.1	Test conditions for class C2 circuit-breakers	169
6.111.9.1.1	Class C2 test-duties	169
6.111.9.1.2	Three-phase line-charging and cable-charging current switching tests	171
6.111.9.1.3	Single-phase line-charging and cable-charging current switching tests	172

6.111.9.1.4	Three-phase capacitor bank (single or back-to-back) current switching tests	172
6.111.9.1.5	Single-phase capacitor bank (single or back-to-back) current switching tests	173
6.111.9.2	Test conditions for class C1 circuit-breakers.....	173
6.111.9.2.1	Class C1 test-duties	173
6.111.9.2.2	Single-phase and three-phase capacitive current switching tests.....	175
6.111.9.3	Test conditions corresponding to breaking in the presence of earth faults	176
6.111.10	Tests with specified TRV	176
6.111.11	Criteria to pass the test.....	177
6.111.11.1	General.....	177
6.111.11.2	Class C2 circuit-breaker.....	177
6.111.11.3	Class C1 circuit-breaker.....	178
6.111.11.4	Criteria for reclassification of a circuit-breaker tested to the class C2 requirements as a class C1 circuit-breaker.....	178
6.112	Special requirements for making and breaking tests on class E2 circuit-breakers	178
6.112.1	Class E2 circuit-breakers intended for use without auto-reclosing duty.....	178
6.112.2	Class E2 circuit-breakers intended for auto-reclosing duty.....	179
7	Routine tests	180
7.1	Dielectric test on the main circuit	180
7.2	Tests on auxiliary and control circuits	180
7.3	Measurement of the resistance of the main circuit	180
7.4	Tightness test.....	180
7.5	Design and visual checks	180
7.101	Mechanical operating tests	181
8	Guidance to the selection of circuit-breakers for service	182
8.101	General	182
8.102	Selection of rated values for service conditions	184
8.102.1	Selection of rated voltage	184
8.102.2	Insulation coordination.....	184
8.102.3	Rated frequency	185
8.102.4	Selection of rated normal current.....	185
8.102.5	Local atmospheric and climatic conditions	185
8.102.6	Use at high altitudes	186
8.103	Selection of rated values for fault conditions.....	186
8.103.1	Selection of rated short-circuit breaking current.....	186
8.103.2	Selection of transient recovery voltage (TRV) for terminal faults, first-pole-to-clear factor and characteristics for short-line faults.....	188
8.103.3	Selection of out-of-phase characteristics	189
8.103.4	Selection of rated short-circuit making current	190
8.103.5	Operating sequence in service.....	190
8.103.6	Selection of rated duration of short-circuit.....	191
8.103.7	Faults in the presence of current limiting reactors	191
8.104	Selection for electrical endurance in networks of rated voltage above 1 kV and up to and including 52 kV.....	192
8.105	Selection for capacitive current switching	192
9	Information to be given with enquiries, tenders and orders	192

9.101	Information to be given with enquiries and orders	192
9.102	Information to be given with tenders	193
10	Rules for transport, storage, installation, operation and maintenance	195
10.1	Conditions during transport, storage and installation.....	195
10.2	Installation.....	195
10.2.101	Commissioning tests.....	195
10.2.102	Commissioning checks and test programme	196
10.2.102.1	Checks after installation	196
10.2.102.1.1	General checks	196
10.2.102.1.2	Checks of electrical circuits	196
10.2.102.1.3	Checks of the insulation and/or extinguishing fluid(s)	196
10.2.102.1.4	Checks on operating fluid(s), where filled or added to on site	197
10.2.102.1.5	Site operations	197
10.2.102.2	Mechanical tests and measurements	197
10.2.102.2.1	Measurements of the characteristic insulating and/or interrupting fluid pressures (where applicable)	197
10.2.102.2.1.1	General	197
10.2.102.2.1.2	Measurements to be taken.....	197
10.2.102.2.2	Measurements of characteristic operating fluid pressures (if applicable)	197
10.2.102.2.2.1	General	197
10.2.102.2.2.2	Measurements to be taken.....	198
10.2.102.2.3	Measurement of consumption during operations (if applicable).....	198
10.2.102.2.4	Verification of the rated operating sequence	198
10.2.102.2.5	Measurement of time quantities	199
10.2.102.2.5.1	Characteristic time quantities of the circuit-breaker.....	199
10.2.102.2.6	Record of mechanical travel characteristics	200
10.2.102.2.7	Checks of certain specific operations	200
10.2.102.2.7.1	Auto-reclosing at the minimum functional pressure for operation (if applicable).....	200
10.2.102.2.7.2	Closing at the minimum functional pressure for operation (if applicable)	200
10.2.102.2.7.3	Opening at the minimum functional pressure for operation (if applicable)	200
10.2.102.2.7.4	Simulation of fault-making operation and check of anti- pumping device	200
10.2.102.2.7.5	Behaviour of the circuit-breaker on a closing command while an opening command is already present.....	201
10.2.102.2.7.6	Application of an opening command on both releases simultaneously (if applicable)	201
10.2.102.3	Electrical tests and measurements	201
10.2.102.3.1	Dielectric tests.....	201
10.2.102.3.2	Measurement of the resistance of the main circuit	201
10.3	Operation	201
10.4	Maintenance	201
11	Safety.....	202
12	Influence of the product on the environment	202

Annex A (normative)	Calculation of transient recovery voltages for short-line faults from rated characteristics	260
---------------------	------------------------------------------------------------------------------------------------------	-----

A.1 Basic approach.....	260
A.2 Transient voltage on line side	262
A.3 Transient voltage on source side	262
A.3.1 Rated voltages of 100 kV and above.....	262
A.3.2 Rated voltages equal and higher than 15 kV and below 100 kV	264
A.4 Examples of calculations	264
A.4.1 Source side and line side with time delay (L_{g0} and L_{75} for 245 kV, 50 kA, 50 Hz)	265
A.4.2 Source side with ITRV, line side with time delay (L_{g0} for 245 kV, 50 kA, 50 Hz)	266
A.4.3 Source side with time delay, line side without time delay (L_{g0} for 245 kV, 50 kA, 50 Hz) – Calculation carried out using a simplified method	266
Annex B (normative) Tolerances on test quantities during type tests.....	270
Annex C (normative) Records and reports of type tests	281
C.1 Information and results to be recorded	281
C.2 Information to be included in type test reports	281
C.2.1 General	281
C.2.2 Apparatus tested	281
C.2.3 Rated characteristics of circuit-breaker, including its operating devices and auxiliary equipment.....	281
C.2.4 Test conditions (for each series of tests)	282
C.2.5 Short-circuit making and breaking tests	282
C.2.6 Short-time withstand current test	283
C.2.7 No-load operation	283
C.2.8 Out-of-phase making and breaking tests.....	283
C.2.9 Capacitive current switching tests.....	283
C.2.10 Oscillographic and other records	284
Annex D (normative) Determination of short-circuit power factor	285
D.1 Method I – Calculation from d.c. component	285
D.1.1 Equation for the d.c. component	285
D.1.2 Phase angle φ	285
D.2 Method II – Determination with pilot generator.....	285
Annex E (normative) Method of drawing the envelope of the prospective transient recovery voltage of a circuit and determining the representative parameters.....	287
E.1 Introduction	287
E.2 Drawing the envelope	287
E.3 Determination of parameters	288
Annex F (normative) Methods of determining prospective transient recovery voltage waves.....	291
F.1 Introduction	291
F.2 General summary of the recommended methods	292
F.3 Detailed consideration of the recommended methods	293
F.3.1 Group 1 – Direct short-circuit breaking	293
F.3.2 Group 2 – Power-frequency current injection	294
F.3.3 Group 3 – Capacitor current injection.....	295
F.3.4 Groups 2 and 3 – Methods of calibration.....	295
F.3.5 Group 4 – Model networks	296
F.3.6 Group 5 – Calculation from circuit parameters	297

F.3.7	Group 6 – No-load switching of test circuits including transformers.....	297
F.3.8	Group 7 – Combination of different methods.....	297
F.4	Comparison of methods.....	297
Annex G (normative)	Rationale behind introduction of circuit-breakers class E2	307
Annex H (informative)	Inrush currents of single and back-to-back capacitor banks.....	308
H.1	General	308
H.2	Example 1 – One capacitor to be switched in parallel (see Figure H.1)	309
H.2.1	Description of the capacitor banks to be switched.....	309
H.2.2	Calculation without any limitation device.....	309
H.2.3	Calculation of limitation devices.....	309
H.3	Example 2 – Two capacitors to be switched in parallel (see Figure H.2)	310
H.3.1	Description of the capacitor banks to be switched.....	310
H.3.2	Calculation without any limitation device.....	310
H.3.3	Calculation of limitation devices.....	311
Annex I (informative)	Explanatory notes.....	313
I.1	General	313
I.2	Explanatory note regarding the d.c. time constant of the rated short-circuit breaking current (4.101.2) – Advice for the choice of the appropriate time constant.....	313
I.2.1	Advice for the choice of the appropriate time constant	313
I.2.2	DC component during T100a testing	313
I.3	Explanatory note regarding capacitive current switching tests (6.111)	315
I.3.1	Restrike performance	315
I.3.2	Test programme	315
I.3.3	Referring to Table 9.....	315
I.3.4	Referring to 6.111.1.....	315
I.3.5	Referring to 6.111.3.....	315
I.3.6	Referring to 6.111.5.....	316
I.3.7	Referring to 6.111.9.1.1	316
I.3.8	Referring to 6.111.9.1.1 and 6.111.9.2.1.....	316
I.3.9	Referring to 6.111.9.1.2 and 6.111.9.1.3.....	316
I.3.10	Referring to 6.111.9.1.2 to 6.111.9.1.5	316
I.3.11	Referring to 6.111.9.1.4 and 6.111.9.1.5.....	317
I.3.12	Referring to 6.111.9.2.....	317
Annex J (informative)	Test current and line length tolerances for short-line fault testing.....	318
Annex K (informative)	List of symbols and abbreviations used in this standard	320
Annex L (informative)	Explanatory notes on the revision of TRVs for circuit-breakers of rated voltages higher than 1 kV and less than 100 kV	327
L.1	General	327
L.2	Terminal fault	327
L.2.1	TRV for circuit-breakers in line systems.....	327
L.2.2	Time delay.....	328
L.2.3	Amplitude factor for T100s and T100a	328
L.2.4	Amplitude factor for T60, T30 and T10.....	328
L.3	Short-line fault.....	329
L.4	Out-of-phase	329
L.5	Series reactor fault	329
L.6	TRV for last clearing poles / Tests circuit topology	330

Annex M (normative) Requirements for breaking of transformer-limited faults by circuit-breakers with rated voltage higher than 1 kV and less than 100 kV	331
M.1 General	331
M.2 Circuit-breakers with rated voltage less than 100 kV.....	332
M.3 Circuit-breakers with rated voltage from 100 kV to 800 kV	334
M.4 Circuit-breakers with rated voltage higher than 800 kV	334
Annex N (normative) Use of mechanical characteristics and related requirements	336
Annex O (informative) Guidance for short-circuit and switching test procedures for metal-enclosed and dead tank circuit-breakers	338
O.1 Introduction	338
O.2 General	338
O.2.1 Special features of metal-enclosed circuit-breakers with respect to making and breaking tests	338
O.2.2 Reduced number of units for testing purposes	338
O.2.3 General description of special features and possible interactions	339
O.3 Tests for single pole in one enclosure	340
O.3.1 Short-circuit making and breaking tests	340
O.3.2 Short-line fault tests	342
O.3.3 Capacitive current switching tests.....	342
O.3.4 Out-of-phase switching	344
O.4 Tests for three poles in one enclosure	345
O.4.1 Terminal fault tests	345
O.4.2 Short-line fault tests	347
O.4.3 Capacitive current switching tests.....	347
O.4.4 Out-of-phase switching test	347
Annex P (normative) Calculation of the TRV parameters during asymmetrical fault condition (T100a).....	350
Annex Q (informative) Examples for the application of the asymmetry criteria during asymmetrical test-duty T100a	355
Q.1 Three-phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current constant longer than the test circuit time constant.....	355
Q.2 Single phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current shorter than the test circuit time constant.....	357
Q.3 Single-phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current longer than the test circuit time constant	358
Annex R (normative) Requirements for circuit-breakers with opening resistors	363
R.1 General	363
R.2 Switching performance to be verified	363
R.2.1 General	363
R.2.2 Tests of the main interrupter	364
R.2.3 Tests on the resistor interrupter	373
R.2.4 Tests of the resistor stack.....	375
R.3 Insertion time of the resistor	376
R.4 Current carrying performance	376
R.5 Dielectric performance.....	376
R.6 Mechanical performance.....	376
R.7 Requirements for the specification of opening resistors	376

R.8 Examples of recovery voltage waveshapes.....	376
R.8.1 General	376
R.8.2 Terminal faults.....	377
R.8.3 Line-charging current breaking	379
 Bibliography.....	 380
 Figure 1 – Typical oscillogram of a three-phase short-circuit make-break cycle	 203
Figure 2 – Circuit-breaker without switching resistors. Opening and closing operations	205
Figure 3 – Circuit breaker without switching resistors – Close-open cycle	206
Figure 4 – Circuit-breaker without switching resistors – Reclosing (auto-reclosing).....	207
Figure 5 – Circuit-breaker with switching resistors. Opening and closing operations	208
Figure 6 – Circuit-breaker with switching resistors – Close-open cycle.....	209
Figure 7 – Circuit-breaker with switching resistors – Reclosing (auto-reclosing).....	210
Figure 8 – Determination of short-circuit making and breaking currents, and of percentage d.c. component.....	211
Figure 9 – Percentage d.c. component in relation to the time interval from the initiation of the short-circuit for the standard different time constants τ_1 and for the special case time constants τ_2, τ_3 and τ_4	212
Figure 10 – Representation of a specified four-parameter TRV and a delay line for T100, T60, short-line fault and out-of-phase condition.....	213
Figure 11 – Representation of a specified TRV by a two-parameter reference line and a delay line	213
Figure 12a – Basic circuit for terminal fault with ITRV	214
Figure 12b – Representation of ITRV in relationship to TRV	214
Figure 13 – Three-phase short-circuit representation	216
Figure 14 – Alternative representation of Figure 13.....	217
Figure 15 – Basic short-line fault circuit	218
Figure 16 – Example of a line side transient voltage with time delay and rounded crest showing construction to derive the values μ_{L^*}, t_L and t_{dL}.....	218
Figure 16a – Example of a line side transient voltage with time delay	219
Figure 16b – Example of line transient voltage with time delay with non-linear rate of rise	219
Figure 16 – Examples of line side transient voltages.....	219
Figure 17 – Test sequences for low and high temperature tests	220
Figure 18 – Humidity test	221
Figure 19 – Static terminal load forces	223
Figure 20 – Directions for static terminal load tests.....	224
Figure 21 – Permitted number of samples for making, breaking and switching tests, illustrations of the statements in 6.102.2	225
Figure 22 – Definition of a single test specimen in accordance with 3.2.2 of IEC 62271-1 ...	226
Figure 23a – Reference mechanical travel characteristics (idealised curve)	227
Figure 23b – 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	227

Figure 23c – 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	228
Figure 23d – 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	228
Figure 24 – Equivalent testing set-up for unit testing of circuit-breakers with more than one separate interrupter units	229
Figure 25a – Preferred circuit	230
Figure 25b – Alternative circuit	230
Figure 25 – Earthing of test circuits for three-phase short-circuit tests, first-pole-to-clear factor 1,5.....	230
Figure 26a – Preferred circuit	231
Figure 26b – Alternative circuit	231
Figure 26 – Earthing of test circuits for three-phase short-circuit tests, first-pole-to-clear factor 1,3.....	231
Figure 27a – Preferred circuit	232
Figure 27b – Alternative circuit not applicable for circuit-breakers where the insulation between phases and/or to earth is critical (e.g. GIS or dead tank circuit-breakers).....	232
Figure 27 – Earthing of test circuits for single-phase short-circuit tests, first-pole-to-clear factor 1,5.....	232
Figure 28a – Preferred circuit	233
Figure 28b – Alternative circuit, not applicable for circuit-breakers where the insulation between phases and/or to earth is critical (e.g. GIS or dead tank circuit-breakers).....	233
Figure 28 – Earthing of test circuits for single-phase short-circuit tests, first-pole-to-clear factor 1,3.....	233
Figure 29 – Example of a graphical representation of the three valid symmetrical breaking operations for three-phase tests in a non-effectively earthed neutral system (first-pole-to-clear factor 1,5)	234
Figure 30 – Example of a graphical representation of the three valid symmetrical breaking operations for three-phase tests in an effectively earthed neutral system (first-pole-to-clear factor 1,3)	235
Figure 31 – Graphical representation of the three valid asymmetrical breaking operations for three-phase tests in a non-effectively earthed neutral system (first-pole-to-clear factor 1,5)	236
Figure 32 – Graphical representation of the three valid asymmetrical breaking operations for three-phase tests in an effectively earthed neutral system (first-pole-to-clear factor 1,3)	237
Figure 33 – Graphical representation of the three valid symmetrical breaking operations for single-phase tests in substitution of three-phase conditions in a non-effectively earthed neutral system (first-pole-to-clear factor 1,5)	238
Figure 34 – Graphical representation of the three valid asymmetrical breaking operations for single-phase tests in substitution of three-phase conditions in a non-effectively earthed neutral system (first-pole-to-clear factor 1,5)	239
Figure 35 – Graphical representation of the three valid symmetrical breaking operations for single-phase tests in substitution of three-phase conditions in an effectively earthed neutral system (first-pole-to-clear factor 1,2 or 1,3)	240
Figure 36 – Graphical representation of the three valid asymmetrical breaking operations for single-phase tests in substitution of three-phase conditions in an effectively earthed neutral system (first-pole-to-clear factor 1,2 or 1,3)	241

Figure 37 – Graphical representation of the interrupting window and the voltage factor k_p , determining the TRV of the individual pole, for systems with a first-pole-to-clear factor of 1,3.....	243
Figure 38 – Graphical representation of the interrupting window and the voltage factor k_p , determining the TRV of the individual pole, for systems with a first-pole-to-clear factor of 1,5.....	243
Figure 39 – Example of prospective test TRV with four-parameter envelope which satisfies the conditions to be met during type test – Case of specified TRV with four-parameter reference line.....	244
Figure 40 – Example of prospective test TRV with two-parameter envelope which satisfies the conditions to be met during type test: case of specified TRV with two-parameter reference line.....	245
Figure 41 – Example of prospective test TRV with four-parameter envelope which satisfies the conditions to be met during type-test – Case of specified TRV with two-parameter reference line.....	246
Figure 42 – Example of prospective test TRV with two-parameter envelope which satisfies the conditions to be met during type-test – Case of specified TRV with four-parameter reference line.....	246
Figure 43 – Example of prospective test TRV-waves and their combined envelope in two-part test	247
Figure 44 – Determination of power frequency recovery voltage	248
Figure 45 – Necessity of additional single-phase tests and requirements for testing	249
Figure 46 – Basic circuit arrangement for short-line fault testing and prospective TRV-circuit-type a) according to 6.109.3: Source side and line side with time delay.....	250
Figure 47 – Basic circuit arrangement for short-line fault testing – circuit type b1) according to 6.109.3: Source side with ITRV and line side with time delay.....	251
Figure 48 – Basic circuit arrangement for short-line fault testing – circuit type b2) according to 6.109.3: Source side with time delay and line side without time delay	252
Figure 49 – Flow-chart for the choice of short-line fault test circuits for class S2 circuit-breakers and for circuit-breakers having a rated voltage of 100 kV and above	253
Figure 50 – Compensation of deficiency of the source side time delay by an increase of the excursion of the line side voltage	254
Figure 51 – Test circuit for single-phase out-of-phase tests	255
Figure 52 – Test circuit for out-of-phase tests using two voltages separated by 120 electrical degrees	255
Figure 53 – Test circuit for out-of-phase tests with one terminal of the circuit-breaker earthed (subject to agreement of the manufacturer).....	256
Figure 54 – Recovery voltage for capacitive current breaking tests	257
Figure 55 – Reclassification procedure for line and cable-charging current switching tests	258
Figure 56 – Reclassification procedure for capacitor bank current switching tests.....	259
Figure 57 – Determination of the major loop to be tested	116
Figure 58 – Graphical representation of the interrupting window and the voltage factor k_p , determining the TRV of the individual pole, for systems with a first-pole-to-clear factor of 1,2.....	242
Figure A.1 – Typical graph of line and source side TRV parameters – Line side and source side with time delay.....	268
Figure A.2 – Typical graph of line and source side TRV parameters – Line side and source side with time delay, source side with ITRV	268
Figure A.3 – Actual course of the source side transient recovery voltage for short-line fault L ₉₀ , L ₇₅ and L ₆₀	269

Figure E.1– Representation by four parameters of a prospective transient recovery voltage of a circuit – Case E.2 c) 1)	289
Figure E.2 – Representation by four parameters of a prospective transient recovery voltage of a circuit – Case E.2 c) 2)	289
Figure E.3 – Representation by four parameters of a prospective transient recovery voltage of a circuit – Case E.2. c) 3) i)	290
Figure E.4 – Representation by two parameters of a prospective transient recovery voltage of a circuit – Case E.2. c) 3) ii)	290
Figure F.1 – Effect of depression on the peak value of the TRV	300
Figure F.2 – TRV in case of ideal breaking	300
Figure F.3 – Breaking with arc-voltage present	301
Figure F.4 – Breaking with pronounced premature current-zero	301
Figure F.5 – Breaking with post-arc current.....	301
Figure F.6 – Relationship between the values of current and TRV occurring in test and those prospective to the system.....	302
Figure F.7 – Schematic diagram of power-frequency current injection apparatus	303
Figure F.8 – Sequence of operation of power-frequency current injection apparatus	304
Figure F.9 – Schematic diagram of capacitance injection apparatus	305
Figure F.10 – Sequence of operation of capacitor-injection apparatus	306
Figure H.1 – Circuit diagram for example 1	309
Figure H.2 – Circuit diagram for example 2	310
Figure H.3 – Equations for the calculation of capacitor bank inrush currents	312
Figure M.1 – First example of transformer-limited fault (also called transformer-fed fault)	331
Figure M.2 – Second example of transformer-limited fault (also called transformer-secondary fault)	332
Figure O.1 – Test configuration considered in Tables O.1 and O.2.....	348
Figure O.2 – Example showing the waveshapes of symmetrical currents, phase-to-ground and phase-to-phase voltages during three-phase interruption, as for Figure 25a	348
Figure O.3 – Example showing the waveshapes of symmetrical currents, phase-to-ground and phase-to-phase voltages during three-phase interruption, as for Figure 26a	349
Figure Q.1 – Three-phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current longer than the test circuit time constant	360
Figure Q.2 – Single phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current shorter than the test circuit time constant	361
Figure Q.3 – Single-phase testing of a circuit-breaker with a rated d.c. time constant of the rated short-circuit breaking current longer than the test circuit time constant	362
Figure R.1 – Typical system configuration for interruption by a circuit-breaker with opening resistors	363
Figure R.2 – Test circuit for test duties T60 and T100	365
Figure R.3 – Test circuit for test duties T10, T30 and OP2	365
Figure R.4 – Example of an underdamped TRV for T100s(b), $U_r = 1\ 100\ \text{kV}$, $I_{SC} = 50\ \text{kA}$, $f_r = 50\ \text{Hz}$	368
Figure R.5 – Example of an overdamped TRV for T10, $U_r = 1\ 100\ \text{kV}$, $I_{SC} = 50\ \text{kA}$, $f_r = 50\ \text{Hz}$	369
Figure R.6 – Example of a test circuit for short-line fault test duty L_{g0}	370
Figure R.7 – Example of real line simulation for short-line fault test-duty L_{g0} based on $U_r = 1\ 100\ \text{kV}$, $I_{SC} = 50\ \text{kA}$ and $f_r = 50\ \text{Hz}$	371

Figure R.8 – Typical recovery voltage waveshape of capacitive current switching on a circuit-breaker equipped with opening resistors	373
Figure R.9 – Typical recovery voltage waveshape of T10 (based on $U_r = 1\ 100\ \text{kV}$, $I_{SC} = 50\ \text{kA}$ and $f_r = 50\ \text{Hz}$) on the resistor interrupter of a circuit-breaker equipped with opening resistors	374
Figure R.10 – TRV waveshapes for high short-circuit current breaking operation	377
Figure R.11 – Currents in case of high short-circuit current breaking operation	377
Figure R.12 – TRV shapes for low short-circuit current breaking operation	378
Figure R.13 – Currents in case of low short-circuit current breaking operation	378
Figure R.14 – Voltage waveshapes for line-charging current breaking operation	379
Figure R.15 – Current waveshapes for line-charging current breaking operation	379
Table 1 – Standard values of transient recovery voltage for class S1 circuit-breakers – Rated voltage higher than 1 kV and less than 100 kV – Representation by two parameters	55
Table 2 – Standard values of transient recovery voltage for class S2 circuit-breakers – Rated voltage equal to or higher than 15 kV and less than 100 kV – Representation by two parameters	56
Table 3 – Standard values of transient recovery voltage – Rated voltages of 100 kV to 170 kV for effectively earthed systems – Representation by four parameters	57
Table 4 – Standard values of transient recovery voltage – Rated voltages of 100 kV to 170 kV for non-effectively earthed systems – Representation by four parameters	58
Table 5 – Standard values of transient recovery voltage – Rated voltages 245 kV and above for effectively earthed systems – Representation by four parameters	59
Table 6 – Standard multipliers for transient recovery voltage values for second and third clearing poles for rated voltages above 1 kV	60
Table 7 – Standard values of initial transient recovery voltage – Rated voltages 100 kV and above	61
Table 8 – Standard values of line characteristics for short-line faults	64
Table 9 – Preferred values of rated capacitive switching currents	66
Table 10 – Nameplate information	74
Table 11 – Type tests	78
Table 12 – Invalid tests	80
Table 13 – Number of operating sequences	91
Table 14 – Examples of static horizontal and vertical forces for static terminal load test	99
Table 15 – Last current loop parameters for 50 Hz operation in relation with short-circuit test-duty T100a $\tau = 45\ \text{ms}$	117
Table 16 – Last current loop parameters for 50 Hz operation in relation with short-circuit test-duty T100a $\tau = 60\ \text{ms}$	118
Table 17 – Last current loop parameters for 50 Hz operation in relation with short-circuit test-duty T100a $\tau = 75\ \text{ms}$	119
Table 18 – Last current loop parameters for 50 Hz operation in relation with short-circuit test-duty T100a $\tau = 120\ \text{ms}$	120
Table 19 – Last current loop parameters for 60 Hz operation in relation with short-circuit test-duty T100a $\tau = 45\ \text{ms}$	121
Table 20 – Last current loop parameters for 60 Hz operation in relation with short-circuit test-duty T100a $\tau = 60\ \text{ms}$	122

Table 21 – Last current loop parameters for 60 Hz operation in relation with short-circuit test-duty T100a $\tau = 75$ ms	123
Table 22 – Last current loop parameters for 60 Hz operation in relation with short-circuit test-duty T100a $\tau = 120$ ms	124
Table 23 – Interrupting window for tests with symmetrical current.....	127
Table 24 – Standard values of prospective transient recovery voltage for class S1 circuit-breakers – Rated voltage higher than 1 kV and less than 100 kV – Representation by two parameters.....	140
Table 25 – Standard values of prospective transient recovery voltage for class S2 circuit-breakers – Rated voltage equal to or higher than 15 kV and less than 100 kV – Representation by two parameters.....	142
Table 25 – Standard values of prospective transient recovery voltage for class S2 circuit-breakers – Rated voltage equal to or higher than 15 kV and less than 100 kV – Representation by two parameters.....	142
Table 26 – Standard values of prospective transient recovery voltage – Rated voltages of 100 kV and above to 800 kV for effectively earthed neutral systems – Representation by four parameters (T100, T60, OP1 and OP2) or two parameters (T30, T10)	143
Table 27 – Standard values of prospective transient recovery voltage – Rated voltages of 100 kV to 170 kV for non-effectively earthed neutral systems – Representation by four parameters (T100, T60, OP1 and OP2) or two parameters (T30 and T10).....	146
Table 28 – TRV parameters for single-phase and double earth fault tests	157
Table 29 – Test-duties to demonstrate the out-of-phase rating.....	164
Table 30 – Class C2 test-duties	169
Table 31 – Class C1 test-duties	174
Table 32 – Specified values of u_1 , t_1 , u_c and t_2	177
Table 33 – Operating sequence for electrical endurance test on class E2 circuit-breakers intended for auto-reclosing duty according to 6.112.2.....	179
Table 34 – Application of voltage for dielectric test on the main circuit.....	180
Table 35 – Relationship between short-circuit power factor, time constant and power frequency.....	187
Table 36 – Rated insulation levels for rated voltages of 1 100 kV and 1 200 kV	47
Table 37 – Peak factors for the rated short-circuit making current.....	62
Table 38 – Test requirements for voltage tests as condition check for GIS and dead tank circuit-breakers.....	84
Table A.1 – Ratios of voltage-drop and source-side TRV	262
Table B.1 – Tolerances on test quantities for type tests	271
Table F.1 – Methods for determination of prospective TRV	298
Table J.1 – Actual percentage short-line fault breaking currents	319
Table M.1 – Standard values of prospective transient recovery voltage for T30, for circuit-breakers intended to be connected to a transformer with a connection of small capacitance – Rated voltage higher than 1 kV and less than 100 kV – Representation by two parameters	334
Table M.2 – Standard values of prospective transient recovery voltage for circuit-breakers with rated voltages higher than 800 kV intended to be connected to a transformer with a connection of low capacitance	335
Table N.1 – Summary of type tests related to mechanical characteristics.....	337
Table O.1 – Three-phase capacitive current switching in actual service conditions: Typical values of voltages on the source-side, load-side, and recovery voltages.....	343

Table O.2 – Corresponding capacitive current-switching tests in accordance with 6.111.7 for single-phase laboratory tests. Values of voltages on the source-side, load-side, and recovery voltages	343
Table O.3 – Test duties T10, T30, T60 and T100s – First-pole-to-clear factor: 1,5. Voltage values during 3-phase interruption	346
Table O.4 – Test duties T10, T30, T60 and T100s – First-pole-to-clear factor: 1,3. Voltage values during 3-phase interruption	346
Table O.5 – Capacitive current switching in actual service conditions: maximum typical voltage values.....	347
Table Q.1 – Example showing the test parameters obtained during a three-phase test when the d.c. time constant of the test circuit is shorter than the rated d.c. time constant of the rated short-circuit current.....	356
Table Q.2 – Example showing the test parameters obtained during a single-phase test when the d.c. time constant of the test circuit is longer than the rated d.c. time constant of the rated short-circuit current.....	357
Table Q.3 – Example showing the test parameters obtained during a single-phase test when the d.c. time constant of the test circuit is shorter than the rated d.c. time constant of the rated short-circuit current.....	359
Table R.1 – Results of the TRV calculation for terminal faults and out-of-phase.....	367
Table R.2 – Results of the TRV calculation for test-duty L _{g0}	371
Table R.3 – Results of the TRV calculations for test-duty T10.....	374

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This consolidated version of IEC 62271-100 consists of the second edition (2008) [documents 17A/815/FDIS and 17A/822/RVD] and its amendment 1 (2012) [documents 17A/1009/FDIS and 17A/1019/RVD]. It bears the edition number 2.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

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

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

- the introduction of harmonised (IEC and IEEE) TRV waveshapes for rated voltages of 100 kV and above (amendment 1 to the first edition);
- the introduction of cable and line systems with their associated TRVs for rated voltages below 100 kV (amendment 2 to the first edition);
- the inclusion of IEC 61633 and IEC 62271-308.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This standard shall be read in conjunction with IEC 62271-1, first edition, published in 2007, 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.

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

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

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

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 100: Alternating-current circuit-breakers

1 General

1.1 Scope

This part of IEC 62271 is applicable to a.c. circuit-breakers designed for indoor or outdoor installation and for operation at frequencies of 50 Hz and 60 Hz on systems having voltages above 1 000 V.

It is only applicable to three-pole circuit-breakers for use in three-phase systems and single-pole circuit-breakers for use in single-phase systems. Two-pole circuit-breakers for use in single-phase systems and application at frequencies lower than 50 Hz are subject to agreement between manufacturer and user.

This standard is also applicable to the operating devices of circuit-breakers and to their auxiliary equipment. However, a circuit-breaker with a closing mechanism for dependent manual operation is not covered by this standard, as a rated short-circuit making-current cannot be specified, and such dependent manual operation may be objectionable because of safety considerations.

Rules for circuit-breakers with an intentional non-simultaneity between the poles are under consideration; circuit-breakers providing single-pole auto-reclosing are within the scope of this standard.

NOTE 1 Circuit-breakers with an intentional ~~non-simultaneity~~ non-simultaneity between the poles may, in some instances, be tested in accordance with this standard. For example, mechanically staggered pole designs can be tested according to this standard using three-phase direct tests. For synthetic testing, determining the most appropriate tests, particularly in respect to test current, recovery voltage and transient recovery voltage, is subject to agreement between manufacturer and user.

This standard does not cover circuit-breakers intended for use on motive power units of electrical traction equipment; these are covered by IEC 60077 [1]¹.

Generator circuit-breakers installed between generator and step-up transformer are not within the scope of this standard.

Switching of inductive loads is covered by IEC 62271-110.

This standard does not cover self-tripping circuit-breakers with ~~mechanical~~ tripping devices ~~or devices which that~~ cannot be made inoperative during testing.

Circuit-breakers installed as by-pass switches in parallel with line series capacitors and their protective equipment are not within the scope of this standard. These are covered by IEC 62271-109 [2] and IEC 60143-2 [3].

NOTE 2 Tests to prove the performance under abnormal conditions should be subject to agreement between manufacturer and user. Such abnormal conditions are, for instance, cases where the voltage is higher than the rated voltage of the circuit-breaker, conditions which may occur due to sudden loss of load on long lines or cables.

¹ Figures in square brackets refer to the bibliography.