

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 2: Circuit-breakers**

**Appareillage à basse tension –
Partie 2: Disjoncteurs**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 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 l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC 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.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables 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 It also gives information on projects, replaced and withdrawn publications.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 online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 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 l'IEC

La Commission Electrotechnique Internationale (IEC) 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 IEC

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

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

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

La recherche avancée permet de trouver des publications IEC 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.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. 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 de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

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.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 2: Circuit-breakers**

**Appareillage à basse tension –
Partie 2: Disjoncteurs**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.130.20

ISBN 978-2-8322-3355-9

**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	14
1 General	16
1.1 Scope and object	16
1.2 Normative references	17
2 Terms and definitions	18
3 Classification	22
4 Characteristics of circuit-breakers	23
4.1 Summary of characteristics	23
4.2 Type of circuit-breaker	23
4.3 Rated and limiting values of the main circuit	23
4.3.1 General	23
4.3.2 Rated voltages	23
4.3.3 Currents	24
4.3.4 Rated frequency	24
4.3.5 Rated duty	24
4.3.6 Short-circuit characteristics	24
4.4 Selectivity categories	27
4.5 Control circuits	27
4.5.1 Electrical control circuits	27
4.5.2 Air-supply control circuits (pneumatic or electro-pneumatic)	27
4.6 Auxiliary circuits	27
4.7 Releases	28
4.7.1 Types	28
4.7.2 Characteristics	28
4.7.3 Current setting of over-current releases	28
4.7.4 Tripping time setting of over-current releases	29
4.8 Integral fuses (integrally fused circuit-breakers)	29
5 Product information	29
5.1 Nature of the information	29
5.2 Marking	29
5.3 Instructions for installation, operation and maintenance	31
6 Normal service, mounting and transport conditions	31
7 Constructional and performance requirements	31
7.1 Constructional requirements	31
7.1.1 General	31
7.1.2 Withdrawable circuit-breakers	31
7.1.3 Additional requirements for circuit-breakers suitable for isolation	32
7.1.4 Clearances and creepage distances	32
7.1.5 Requirements for the safety of the operator	32
7.1.6 List of construction breaks	32
7.1.7 Additional requirements for circuit-breakers provided with a neutral pole	33
7.1.8 Digital inputs and outputs for use with programmable logic controllers (PLCs)	33
7.2 Performance requirements	33
7.2.1 Operating conditions	33

7.2.2	Temperature-rise	36
7.2.3	Dielectric properties	37
7.2.4	Ability to make and break under no load, normal load and overload conditions	37
7.2.5	Ability to make and break under short-circuit conditions	38
7.2.6	Vacant	39
7.2.7	Additional requirements for circuit-breakers suitable for isolation	39
7.2.8	Specific requirements for integrally fused circuit-breakers	39
7.2.9	Co-ordination between a circuit-breaker and another short-circuit protective device	39
7.3	Electromagnetic compatibility (EMC)	39
8	Tests	39
8.1	Kind of tests	39
8.1.1	General	39
8.1.2	Type tests	39
8.1.3	Routine tests	40
8.2	Compliance with constructional requirements	40
8.3	Type tests	40
8.3.1	Test sequences	40
8.3.2	General test conditions	48
8.3.3	Test sequence I: General performance characteristics	56
8.3.4	Test sequence II: Rated service short-circuit breaking capacity	65
8.3.5	Test sequence III: Rated ultimate short-circuit breaking capacity	66
8.3.6	Test sequence IV: Rated short-time withstand current	68
8.3.7	Test sequence V: Performance of integrally fused circuit-breakers	69
8.3.8	Test sequence VI: combined test sequence	71
8.3.9	Critical d.c. load current test	73
8.4	Routine tests	74
8.4.1	General	74
8.4.2	Mechanical operation tests	74
8.4.3	Verification of the calibration of overcurrent releases	75
8.4.4	Verification of the operation of undervoltage and shunt releases	75
8.4.5	Additional tests for CBRs	75
8.4.6	Dielectric tests	76
8.4.7	Test for the verification of clearances less than those corresponding to case A of Table 13 of IEC 60947-1:2007	77
8.5	Special tests – Damp heat, salt mist, vibration and shock	77
Annex A (normative)	Co-ordination between a circuit-breaker and another short-circuit protective device associated in the same circuit	79
A.1	General	79
A.2	Scope and object	79
A.3	General requirements for the co-ordination of a circuit-breaker with another SCPD	80
A.3.1	General considerations	80
A.3.2	Take-over current	80
A.3.3	Behaviour of C_1 in association with another SCPD	80
A.4	Type and characteristics of the associated SCPD	80
A.5	Verification of selectivity	81
A.5.1	General	81
A.5.2	Consideration of selectivity by desk study	81

A.5.3	Selectivity determined by test.....	82
A.6	Verification of back-up protection	83
A.6.1	Determination of the take-over current.....	83
A.6.2	Verification of back-up protection	83
A.6.3	Tests for verification of back-up protection	83
A.6.4	Results to be obtained	84
Annex B (normative)	Circuit-breakers incorporating residual current protection.....	90
B.1	General	90
B.1.1	Preamble	90
B.1.2	Scope and object	90
B.2	Terms and definitions.....	91
B.2.1	Terms and definitions relating to currents flowing from live parts to earth.....	91
B.2.2	Terms and definitions relating to the energization of a CBR	91
B.2.3	Terms and definitions relating to the operation and the functions of a CBR	92
B.2.4	Terms and definitions relating to values and ranges of energizing quantities.....	93
B.3	Classification	94
B.3.1	Classification according to the method of operation of the residual current function.....	94
B.3.2	Classification according to the possibility of adjusting the residual operating current	94
B.3.3	Classification according to time-delay of the residual current function	94
B.3.4	Classification according to behaviour in presence of a d.c. component.....	94
B.4	Characteristics of CBRs concerning their residual current function.....	94
B.4.1	Rated values.....	94
B.4.2	Preferred and limiting values	95
B.4.3	Value of the rated residual short-circuit making and breaking capacity ($I_{\Delta m}$)	96
B.4.4	Operating characteristics in case of an earth fault current in the presence or absence of a d.c. component	96
B.5	Marking	96
B.6	Normal service, mounting and transport conditions	97
B.7	Design and operating requirements	98
B.7.1	Design requirements	98
B.7.2	Operating requirements.....	98
B.7.3	Electromagnetic compatibility	100
B.8	Tests	100
B.8.1	General.....	100
B.8.2	Verification of the operating characteristic	103
B.8.3	Verification of dielectric properties.....	105
B.8.4	Verification of the operation of the test device at the limits of rated voltage	105
B.8.5	Verification of the limiting value of the non-operating current under over-current conditions	105
B.8.6	Verification of the resistance against unwanted tripping due to surge currents resulting from impulse voltages	106
B.8.7	Verification of the behaviour of CBRs of type A in the case of an earth fault current comprising a d.c. component	107

B.8.8	Verification of the behaviour of CBRs functionally dependent on line voltage classified under B.3.1.2.1	108
B.8.9	Verification of the behaviour of CBRs functionally dependent on line voltage as classified under B.3.1.2.2 in the case of failure of line voltage	109
B.8.10	Verification of the residual short-circuit making and breaking capacity	110
B.8.11	Verification of the effects of environmental conditions	111
B.8.12	Verification of electromagnetic compatibility	111
B.8.13	Test for variations or interruptions of voltage and for voltage dips	113
Annex C (normative)	Individual pole short-circuit test sequence	121
C.1	General	121
C.2	Test of individual pole short-circuit breaking capacity	121
C.3	Verification of dielectric withstand	121
C.4	Verification of overload releases	121
Annex D	Vacant	122
Annex E (informative)	Items subject to agreement between manufacturer and user	123
Annex F (normative)	Additional tests for circuit-breakers with electronic over-current protection	124
F.1	General	124
F.2	List of tests	124
F.2.1	General	124
F.2.2	Electromagnetic compatibility (EMC) tests	124
F.2.3	Suitability for multiple frequencies	125
F.2.4	Dry heat test	125
F.2.5	Damp heat test	125
F.2.6	Temperature variation cycles at a specified rate of change	125
F.3	General test conditions	125
F.3.1	General	125
F.3.2	Electromagnetic compatibility tests	125
F.4	Immunity tests	126
F.4.1	Harmonic currents	126
F.4.2	Electrostatic discharges	127
F.4.3	Radiated RF electromagnetic fields	127
F.4.4	Electrical fast transient/burst (EFT/B)	127
F.4.5	Surges	128
F.4.6	Conducted disturbances induced by RF fields (common mode)	128
F.4.7	Current dips	128
F.5	Emission tests	129
F.5.1	Harmonics	129
F.5.2	Voltage fluctuations	129
F.5.3	Conducted RF disturbances (150 kHz to 30 MHz)	129
F.5.4	Radiated RF disturbances (30 MHz to 1 GHz)	129
F.6	Suitability for multiple frequencies	130
F.6.1	General	130
F.6.2	Test conditions	130
F.6.3	Test procedure	130
F.6.4	Test results	130
F.7	Dry heat test	131
F.7.1	Test procedure	131

F.7.2	Test results	131
F.7.3	Verification of overload releases	131
F.8	Damp heat test	131
F.8.1	Test procedure.....	131
F.8.2	Verification of overload releases	131
F.9	Temperature variation cycles at a specified rate of change	131
F.9.1	Test conditions.....	131
F.9.2	Test procedure.....	132
F.9.3	Test results.....	132
F.9.4	Verification of overload releases	132
Annex G (normative)	Power loss	145
G.1	General	145
G.2	Test methods	145
G.2.1	General case	145
G.2.2	AC circuit-breakers of rated current not exceeding 400 A.....	145
G.2.3	DC circuit-breakers	146
G.3	Test procedure.....	146
Annex H (normative)	Test sequence for circuit-breakers for IT systems	148
H.1	General	148
H.2	Individual pole short-circuit	148
H.3	Verification of dielectric withstand	149
H.4	Verification of overload releases	149
H.5	Marking	149
Annex J (normative)	Electromagnetic compatibility (EMC) – Requirements and test methods for circuit-breakers	150
J.1	General	150
J.2	Immunity.....	151
J.2.1	General.....	151
J.2.2	Electrostatic discharges	153
J.2.3	Radiated RF electromagnetic fields	154
J.2.4	Electrical fast transients/bursts (EFT/B).....	154
J.2.5	Surges.....	154
J.2.6	Conducted disturbances induced by RF fields (common mode).....	155
J.3	Emission.....	155
J.3.1	General.....	155
J.3.2	Conducted RF disturbances (150 kHz to 30 MHz).....	156
J.3.3	Radiated RF disturbances (30 MHz to 1 000 MHz).....	156
Annex K (informative)	Glossary of symbols and graphical representation of characteristics	161
Annex L (normative)	Circuit-breakers not fulfilling the requirements for overcurrent protection	170
L.1	General	170
L.2	Terms and definitions.....	170
L.3	Classification	170
L.4	Rated values.....	170
L.4.1	Rated current (I_n).....	170
L.4.2	Rated conditional short-circuit current (I_{cc})	171
L.5	Product information.....	171
L.6	Constructional and performance requirements.....	171

L.7	Tests	171
L.7.1	General.....	171
L.7.2	Rated conditional short-circuit tests.....	172
Annex M (normative) Modular residual current devices (without integral current breaking device).....		175
M.1	General	175
M.1.1	Field of application	175
M.1.2	Field of application.....	175
M.2	Terms and definitions.....	175
M.2.1	Terms and definitions relating to the energization of an MRCD	175
M.2.2	Terms and definitions relating to the operation and the functions of an MRCD	176
M.3	Classification	176
M.3.1	Classification according to the configuration of the primary conductors	176
M.3.2	Classification according to the method of operation	177
M.3.3	Classification according to the possibility of adjusting the residual operating current	177
M.3.4	Classification according to time-delay of the residual current function	177
M.3.5	Classification according to behaviour in presence of a d.c. component.....	177
M.4	Characteristics of MRCDs	177
M.4.1	General characteristics	177
M.4.2	Characteristics of MRCDs concerning their residual current function.....	178
M.4.3	Behaviour under short-circuit conditions	179
M.4.4	Preferred and limiting values.....	179
M.5	Product information.....	180
M.6	Normal service, mounting and transport conditions	182
M.7	Design and operating requirements	182
M.7.1	Design requirements	182
M.7.2	Operating requirements.....	182
M.8	Tests	184
M.8.1	General.....	184
M.8.2	Compliance with constructional requirements	185
M.8.3	Verification of the operating characteristics	186
M.8.4	Verification of dielectric properties.....	188
M.8.5	Verification of the operation of the test device at the limits of the rated voltage	189
M.8.6	Verification of the limiting value of non-operating current under overcurrent conditions, in case of a single phase load	189
M.8.7	Resistance against unwanted tripping due to surge currents resulting from impulse voltages	189
M.8.8	Verification of the behaviour in case of an earth fault current comprising a d.c. component.....	189
M.8.9	Verification of the behaviour of MRCDs with separate sensing means in case of a failure of the sensing means connection	192
M.8.10	Verification of temperature-rise of terminal type MRCDs	192
M.8.11	Verification of mechanical and electrical endurance	193
M.8.12	Verification of the behaviour of MRCDs in case of failure of the voltage source for MRCDs classified under M.3.2.2.1	193
M.8.13	Verification of the behaviour of MRCDs with voltage source as classified under M.3.2.2.2 in case of failure of the voltage source	194

M.8.14	Verification of the behaviour of the MRCD under short-circuit conditions	194
M.8.15	Verification of effects of environmental conditions.....	196
M.8.16	Verification of electromagnetic compatibility	197
Annex N (normative) Electromagnetic compatibility (EMC) – Additional requirements and test methods for devices not covered by Annex B, Annex F and Annex M		219
N.1	General	219
N.1.1	General.....	219
N.1.2	General test conditions	219
N.2	Immunity.....	219
N.2.1	General.....	219
N.2.2	Electrostatic discharges	220
N.2.3	Radiated RF electromagnetic fields	220
N.2.4	Electrical fast transients/bursts (EFT/B).....	220
N.2.5	Surges	221
N.2.6	Conducted disturbances induced by RF fields (common mode).....	221
N.2.7	Voltage dips and interruptions	221
N.3	Emission.....	221
N.3.1	General.....	221
N.3.2	Conducted RF disturbances (150 kHz to 30 MHz).....	222
N.3.3	Radiated RF disturbances (30 MHz to 1 000 MHz).....	222
Annex O (normative) Instantaneous trip circuit-breakers (ICB)		223
O.1	General	223
O.2	Terms and definitions.....	223
O.3	Rated values.....	223
O.3.1	General.....	223
O.3.2	Rated current (I_n).....	223
O.3.3	Rated short-circuit making capacity	223
O.3.4	Rated short-circuit breaking capacities	223
O.4	Product information.....	224
O.5	Constructional and performance requirements.....	224
O.6	Tests	224
O.6.1	Test sequence of the ICB alone.....	224
O.6.2	ICB associated with a specified protected device (i.e. motor-starter or overload relay).....	225
Annex P (normative) DC circuit-breakers for use in photovoltaic (PV) applications.....		226
P.1	Field of application.....	226
P.2	Terms and definitions.....	226
P.3	Classification	226
P.4	Characteristics of PV circuit-breakers.....	226
P.5	Product information.....	227
P.6	Normal service, mounting and transport conditions	227
P.7	Constructional and performance requirements.....	227
P.7.1	Constructional requirements.....	227
P.7.2	Performance requirements	227
P.7.3	Electromagnetic compatibility (EMC)	228
P.8	Tests	228
P.8.1	Kind of tests.....	228
P.8.2	Compliance with constructional requirements	228

P.8.3	Type tests	228
P.8.4	Routine tests	230
P.8.5	Special tests	230
Annex Q	Vacant	231
Annex R (normative)	Circuit-breakers incorporating residual current protection with automatic re-closing functions	232
R.1	General	232
R.1.1	Preamble	232
R.1.2	Field of application	232
R.2	Terms and definitions	233
R.3	Classification	234
R.3.1	According to the method of construction	234
R.3.2	According to the method of automatic reclosing	234
R.4	Characteristics	234
R.4.1	Rated automatic reclosing operating residual current ($I_{\Delta ar}$)	234
R.4.2	Maximum number of consecutive reclosing operations	234
R.5	Marking and instructions	235
R.6	Normal service, mounting and transport conditions	235
R.7	Design and operating requirements	235
R.7.1	Design requirements	235
R.7.2	Operating requirements	236
R.8	Tests	237
R.8.1	General conditions	237
R.8.2	Verification of the non-reclosing after tripping under over-current conditions	237
R.8.3	Verification of the non-reclosing after intentional opening	238
R.8.4	Verification of the automatic reclosing function after tripping on earth fault	238
R.8.5	Verification of mechanical endurance	239
R.8.6	Verification of the isolation function	240
R.8.7	Verification of residual short-circuit making and breaking capacity	240
R.8.8	Verification of the automatic reclosing function after the test sequences of Clause B.8	240
R.8.9	Test items for external type automatic reclosing devices	241
Bibliography		243
Figure 1	– Test arrangement (connecting cables not shown) for short-circuit tests	78
Figure A.1	– Over-current co-ordination between a circuit-breaker and a fuse or back-up protection by a fuse: operating characteristics	85
Figure A.2	– Total selectivity between two circuit-breakers	86
Figure A.3	– Back-up protection by a circuit-breaker – Operating characteristics	87
Figure A.4	– Example of test circuit for conditional short-circuit breaking capacity tests showing cable connections for a 3-pole circuit-breaker (C_1)	88
Figure A.5	– Example of test circuit for the verification of selectivity	89
Figure B.1	– Test circuit for the verification of the operating characteristic (see B.8.2)	114
Figure B.2	– Test circuit for the verification of the limiting value of the non-operating current under over-current conditions (see B.8.5)	115
Figure B.3	– Test circuit for the verification of the behaviour of CBRs classified under B.3.1.2.2 (see B.8.9)	116

Figure B.4 – Current ring wave 0,5 μ s/100 kHz	117
Figure B.5 – Example of test circuit for the verification of resistance to unwanted tripping	117
Figure B.6 – Surge current wave 8/20 μ s	118
Figure B.7 – Test circuit for the verification of resistance to unwanted tripping in case of flashover without follow-on current (B.8.6.3).....	118
Figure B.8 – Test circuit for the verification of the correct operation of CBRs, in the case of residual pulsating direct currents (see B.8.7.2.1, B.8.7.2.2 and B.8.7.2.3)	119
Figure B.9 – Test circuit for the verification of the correct operation of CBRs, in the case of a residual pulsating direct current superimposed by a smooth direct residual current (see B.8.7.2.4)	120
Figure F.1 – Representation of test current produced by back-to-back thyristors in accordance with F.4.1	133
Figure F.2 – Test circuit for immunity and emission tests in accordance with F.4.1.3, F.4.2, F.4.3, F.4.6, F.4.7.1, F.5.4 and F.6.3 – Two phase poles in series	133
Figure F.3 – Test circuit for immunity and emission tests in accordance with F.4.1.3, F.4.2, F.4.3, F.4.6, F.4.7.1, F.5.4 and F.6.3 – Three phase poles in series	134
Figure F.4 – Test circuit for immunity and emission tests in accordance with F.4.1.3, F.4.2, F.4.3, F.4.6, F.4.7.1, F.5.4 and F.6.3 – Three-phase connection	134
Figure F.5 – Test current for the verification of the influence of the current dips and interruptions in accordance with F.4.7.1	135
Figure F.6 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.4 – Two phase poles in series	135
Figure F.7 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.4 – Three phase poles in series	136
Figure F.8 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.4 – Three-phase connection	136
Figure F.9 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.5 – Two phase poles in series	137
Figure F.10 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.5 – Three phase poles in series.....	137
Figure F.11 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.5 – Three-phase connection	138
Figure F.12 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.5 – Two phase poles in series.....	138
Figure F.13 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.5 – Three phase poles in series	139
Figure F.14 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.5 – Three-phase connection.....	139
Figure F.15 – Temperature variation cycles at a specified rate of change in accordance with F.9.1	140
Figure F.16 – General test set-up for immunity tests	141
Figure F.17 – Test set-up for the verification of immunity to radiated RF electromagnetic fields	141
Figure F.18 – Test set-up for the verification of immunity to electrical fast transients/bursts (EFT/B) on power lines	142
Figure F.19 – Test set-up for verification of immunity to electrical fast transients/bursts (EFT/B) on signal lines	142
Figure F.20 – General test set-up for the verification of immunity to conducted disturbances induced by RF fields (common mode)	142

Figure F.21 – Arrangement of connections for the verification of immunity to conducted disturbances induced by RF fields – Two phase poles in series configuration	143
Figure F.22 – Arrangement of connections for the verification of immunity to conducted disturbances induced by RF fields – Three phase poles in series configuration	143
Figure F.23 – Arrangement of connections for the verification of immunity to conducted disturbances induced by RF fields – Three-phase configuration	144
Figure G.1 – Example of power loss measurement according to G.2.1	146
Figure G.2 – Example of power loss measurement according to G.2.2 and G.2.3	147
Figure J.1 – EUT mounted in a metallic enclosure	157
Figure J.2 – Test set up for the measurement of radiated RF emissions	158
Figure J.3 – Test set up for the verification of immunity to electrostatic discharges	159
Figure J.4 – Test set up for the verification of immunity to radiated RF electromagnetic fields	159
Figure J.5 – Test set up for the verification of immunity to electrical fast transients/bursts (EFT/B) on power lines	160
Figure J.6 – Test set up for the verification of immunity to electrical fast transients/bursts (EFT/B) on signal lines	160
Figure K.1 – Relationship between symbols and tripping characteristics	163
Figure K.2 – Template for characteristics of cut-off current versus prospective current from 1 kA to 200 kA	164
Figure K.3 – Template for characteristics of cut-off current versus prospective current from 0,01 kA to 200 kA	165
Figure K.4 – Template for characteristics of let-through energy versus prospective current from 1 kA to 200 kA	166
Figure K.5 – Template for characteristics of let-through energy versus prospective current from 0,01 kA to 200 kA	167
Figure K.6 – Example of the use of template to Figure K.2	168
Figure K.7 – Example of the use of template to Figure K.4	169
Figure M.1 – Test circuits for the verification of operation in the case of a steady increase of residual current	198
Figure M.2 – Test circuits for the verification of operation in the case of a sudden appearance of residual current (with breaking device)	199
Figure M.3 – Test circuits for the verification of operation in the case of a sudden appearance of residual current (without breaking device)	200
Figure M.4 – Test circuits for the verification of the limiting value of non-operating current under overcurrent conditions	201
Figure M.5 – Test circuits for the verification of the resistance to unwanted tripping in the case of loading of the network capacitance	202
Figure M.6 – Test circuit for the verification of the resistance to unwanted tripping in the case of flashover without follow-on current	203
Figure M.7 – Test circuits for the verification of operation in the case of a continuous rise of a residual pulsating direct current	204
Figure M.8 – Test circuits for the verification of operation in the case of a sudden appearance of residual pulsating direct current (without breaking device)	205
Figure M.9 – Test circuits for the verification of operation in the case of a sudden appearance of residual pulsating direct current (with breaking device)	206
Figure M.10 – Test circuits for the verification of operation in the case of a residual pulsating direct current superimposed by smooth direct current of 6 mA	207

Figure M.11 – Test circuits for the verification of operation in the case of a slowly rising residual smooth direct current	208
Figure M.12 – Test circuits for the verification of operation in the case of a sudden appearance of residual smooth direct current (without breaking device)	209
Figure M.13 – Test circuits for the verification of operation in the case of a sudden appearance of residual smooth direct current (with breaking device)	210
Figure M.14 – Test circuits for the verification of operation in the case of a slowly rising residual current resulting from a fault in a circuit fed by a three-pulse star or a six-pulse bridge connection	211
Figure M.15 – Test circuits for the verification of operation in the case of a slowly rising residual current resulting from a fault in a circuit fed by a two-pulse bridge connection line-to-line	212
Figure M.16 – Test circuit for the verification of the behaviour of MRCDs with separate sensing means in the case of a failure of the sensor means connection	213
Figure M.17 – Test circuit for the verification of the behaviour of MRCD with separate sensing means under short-circuit conditions	214
Figure M.18 – Test circuit for the verification of the behaviour of MRCD with integral sensing means under short-circuit conditions	215
Figure M.19 – Test circuit for the verification of the behaviour of terminal type MRCD under short-circuit conditions	216
Figure M.20 – Verification of immunity to radiated RF electromagnetic fields – Test set-up for MRCD with separate sensing means (additional to the test of Annex B)	217
Figure M.21 – Verification of immunity to electrical fast transients/bursts (EFT/B) on the sensing means connection of an MRCD with separate sensing means (additional to the test of Annex B)	218
Figure M.22 – Verification of immunity to conducted disturbances induced by RF fields – Test set up for MRCD with separate sensing means (additional to the test of Annex B)	218
Figure R.1 – Test circuit for the verification of the automatic reclosing functions	242
Table 1 (void)	26
Table 2 – Ratio n between short-circuit making capacity and short-circuit breaking capacity and related power factor (for a.c. circuit-breakers)	26
Table 3 – Minimum values of rated short-time withstand current	27
Table 4 (void)	27
Table 5 – Preferred values of the rated control supply voltage, if different from that of the main circuit	27
Table 6 – Characteristics of the opening operation of inverse time-delay over-current opening releases at the reference temperature	35
Table 7 – Temperature-rise limits for terminals and accessible parts	36
Table 8 – Number of operating cycles	38
Table 9 – Overall schema of test sequences ^a	43
Table 9a – Applicability of test sequences according to the relationship between I_{CS} , I_{CU} and I_{CW} ^a	44
Table 9b – Applicability of tests or test sequences to 1, 2 and 4-pole circuit-breakers according to the alternative programme 1 of 8.3.1.4	46
Table 9c – Applicability of tests or test sequences to 1, 2 and 3-pole circuit-breakers according to the alternative programme 2 of 8.3.1.4	47
Table 10 – Number of samples for test (1 of 2)	50
Table 11 – Values of power factors and time constants corresponding to test currents	52

Table 12 – Test circuit characteristics for overload performance.....	64
Table B.1 – Operating characteristic for non-time-delay type	95
Table B.2 – Operating characteristic for time-delay type having a limiting non-actuating time of 0,06 s.....	96
Table B.3 – Requirements for CBRs functionally dependent on line voltage	100
Table B.4 – Additional test sequences	102
Table B.5 – Tripping current range for CBRs in case of an earth fault comprising a d.c. component.....	107
Table F.1 – Test parameters for current dips and interruptions	129
Table J.1 – EMC – Immunity tests.....	152
Table J.2 – Reference data for immunity test specifications.....	153
Table J.3 – EMC – Emission tests.....	156
Table J.4 – Reference data for emission test specifications.....	156
Table M.1 – Product information	181
Table M.2 – Requirements for MRCDs with voltage source.....	183
Table M.3 – Test sequences	185
Table P.1 – Rated impulse withstand levels for PV circuit-breakers	226
Table P.2 – Number of operating cycles	228
Table R.1 – Test sequences for external type automatic re-closing devices	241

Preview generated by EVS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**Part 2: 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.

International Standard IEC 60947-2 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage.

This fifth edition cancels and replaces the fourth edition published in 2006, Amendment 1:2009 and Amendment 2:2013. This edition constitutes a technical revision.

This edition includes the following significant additions with respect to the previous edition:

- tests for verification of selectivity in Annex A (see A.5.3);
- critical load current tests for d.c. circuit-breakers (see 8.3.9);
- new Annex P for circuit-breakers for use in photovoltaic applications;
- new Annex R for residual-current circuit-breakers with automatic reclosing functions.

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

FDIS	Report on voting
121A/71/FDIS	121A/83/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.

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

A list of all parts in the IEC 60947 series, published under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

This International Standard is to be used in conjunction with IEC 60947-1:2007 and its Amendment 1:2010 and Amendment 2:2014.

The provisions of the general rules dealt with in IEC 60947-1 are applicable to this standard, where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1 and its amendments when applicable, for example, 1.2.3 of IEC 60947-1:2007, Table 4 of IEC 60947-1:2007/AMD1:2010, or Annex A of IEC 60947-1:2007/AMD1:2010/AMD2:2014.

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

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

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

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 2: Circuit-breakers

1 General

1.1 Scope and object

This part of IEC 60947 series applies to circuit-breakers, the main contacts of which are intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.; it also contains additional requirements for integrally fused circuit-breakers.

Circuit-breakers rated above 1 000 V a.c. but not exceeding 1 500 V a.c. may also be tested to this standard.

It applies whatever the rated currents, the method of construction or the proposed applications of the circuit-breakers may be.

The requirements for circuit-breakers which are also intended to provide earth leakage protection are contained in Annex B.

The additional requirements for circuit-breakers with electronic over-current protection are contained in Annex F.

The additional requirements for circuit-breakers for IT systems are contained in Annex H.

The requirements and test methods for electromagnetic compatibility of circuit-breakers are contained in Annex J.

The requirements for circuit-breakers not fulfilling the requirements for over-current protection are contained in Annex L.

The requirements for modular residual current devices (without integral current breaking device) are contained in Annex M.

The requirements and test methods for electromagnetic compatibility of circuit-breaker auxiliaries are contained in Annex N.

The requirements and test methods for d.c. circuit-breakers for use in photovoltaic (PV) applications are contained in Annex P.

The requirements and test methods for circuit-breakers incorporating residual current protection with automatic reclosing functions are contained in Annex R.

Supplementary requirements for circuit-breakers used as direct-on-line starters are given in IEC 60947-4-1, applicable to low-voltage contactors and starters.

The requirements for circuit-breakers for the protection of wiring installations in buildings and similar applications, and designed for use by uninstructed persons, are contained in IEC 60898.

The requirements for circuit-breakers for equipment (for example electrical appliances) are contained in IEC 60934.

For certain specific applications (for example traction, rolling mills, marine service) particular or additional requirements may be necessary.

NOTE Circuit-breakers which are dealt with in this standard can be provided with devices for automatic opening under predetermined conditions other than those of over-current and undervoltage as, for example, reversal of power or current. This standard does not deal with the verification of operation under such pre-determined conditions.

The object of this standard is to state:

- a) the characteristics of circuit-breakers;
- b) the conditions with which circuit-breakers shall comply with reference to:
 - 1) operation and behaviour in normal service;
 - 2) operation and behaviour in case of overload and operation and behaviour in case of short-circuit, including co-ordination in service (selectivity and back-up protection);
 - 3) dielectric properties;
- c) tests intended for confirming that these conditions have been met and the methods to be adopted for these tests;
- d) information to be marked on or given with the apparatus.

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 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-1:2007/AMD1:2010

IEC 60947-1:2007/AMD2:2014

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
 IEC 61000-4-3:2006/AMD1:2007
 IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 62475:2010, *High-current test techniques – Definitions and requirements for test currents and measuring systems*

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

2 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60947-1, as well as the following apply.

NOTE Where these definitions are taken unchanged from the *International Electrotechnical Vocabulary (IEV)*, IEC 60050-441, the reference to this publication is given in brackets.

2.1

circuit-breaker

a 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

[SOURCE: IEC 60050-441:1984, 441-14-20]

2.1.1

frame size

a term designating a group of circuit-breakers, the external physical dimensions of which are common to a range of current ratings.

Note 1 to entry: Frame size is expressed in amperes corresponding to the highest current rating of the group.

Note 2 to entry: Within a frame size, the width may vary according to the number of poles.

Note 3 to entry: This definition does not imply dimensional standardization.