



DPC: 24 / 30490272 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Title: BS EN IEC 63053-2 Residual current operated circuit-breakers for household and similar uses for dc systems

Part 2: Residual current operated circuit breakers without integral overcurrent protection (DC-RCCBs)

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Responsible Committee Secretary: **Mr Simon Bounds (BSI)**Direct tel: **0208 996 7281**E-mail: simon.bounds@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



23E/1393/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 63053-2 ED1	
DATE OF CIRCULATION: 2024-12-13	CLOSING DATE FOR COMMENTS: 2025-03-07
SUPERSEDES DOCUMENTS: 23E/1343/NP, 23E/1350/RVN	

IEC SC 23E : CIRCUIT-BREAKERS AND SIMILAR EQUIPMENT FOR HOUSEHOLD USE		
SECRETARIAT: Italy		SECRETARY: Mr Giovanni Cassinelli
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 64, SC 121A		HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED: Electromagnetic Compatibility, Safety		

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TITLE: Residual current operated circuit-breakers for household and similar uses for dc systems - Part 2: Residual current operated circuit breakers without integral overcurrent protection (DC-RCCBs)

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CONTENTS

FOREWORD.....	10
INTRODUCTION.....	12
1 Scope.....	13
2 Normative references	14
3 Terms and definitions	14
4 Classification.....	15
4.1 According to the supply conditions	15
4.1.1 DC-RCCB operating correctly on the occurrence of residual current	15
4.1.2 RCCB with 2 or 4 current paths operating correctly on the occurrence of residual current within the voltage range of 1,1 U_e and 90 V.....	15
4.1.3 RCCB according to 4.1.2 fitted with a functional earth (FE) and able to continue to provide protection when supplied from just one line and FE.....	15
4.1.4 RCCB operating correctly on the occurrence of residual current within the voltage range 1,1 U_e and U_x	15
4.1.5 RCCB according to 4.1.4, however reclosing automatically after restoration of the supply voltage.....	15
4.2 According to the possibility of adjusting the residual operating current.....	15
4.2.1 DC-RCCB with a single value of rated residual operating current.....	15
4.2.2 DC-RCCB with multiple settings of residual operating current by fixed steps	15
4.3 According to behaviour of residual direct current type	15
4.3.1 DC-RCCB Type DC for smooth direct current	15
4.3.2 DC-RCCB Type DC+ for non-smooth direct current.....	15
4.4 According to time-delay (in presence of a residual current)	16
4.4.1 DC-RCCB without time-delay: type for general use	16
4.4.2 DC-RCCB with time-delay: type S with time-delay of 0,06 s for selectivity	16
4.5 According to the protection against external influences	16
4.5.1 Enclosed-type DC-RCCB (not requiring an appropriate enclosure)	16
4.5.2 Unenclosed-type DC-RCCB (for use with an appropriate enclosure)	16
4.6 According to the method of mounting	16
4.6.1 Surface-type DC-RCCB	16
4.6.2 Flush-type DC-RCCB.....	16
4.6.3 Panel board type DC-RCCB, also referred to as distribution board type	16
4.7 According to the method of connection	16
4.7.1 DC-RCCB, the electrical connections of which are not associated with the mechanical mounting	16
4.7.2 DC-RCCB, the electrical connections of which are associated with the mechanical mounting	16
4.8 According to the type of terminals	16
4.8.1 DC-RCCB with screw-type terminals for external copper conductors.....	16
4.8.2 DC-RCCB with screwless type terminals for external copper conductors.....	16
4.8.3 DC-RCCB with flat quick-connect terminals for external copper conductors.....	16
4.9 According to the number of poles and current paths.....	16
4.9.1 Single-pole DC-RCCB with two current paths	16

51	4.9.2	Two-pole DC-RCCB.....	16
52	4.9.3	Two-pole DC-RCCB with three current paths	16
53	4.9.4	Three-pole DC-RCCB	17
54	4.10	According to the current direction through the poles	17
55	4.10.1	Polarised DC-RCCB	17
56	4.10.2	Non-polarised DC-RCCB	17
57	4.11	According to the supply side of the device (directionality)	17
58	4.11.1	DC-RCCB to be supplied on one specific side (uni-directional)	17
59	4.11.2	DC-RCCB to be supplied on any side (bi-directional)	17
60	5	Characteristics of DC-RCCBs	17
61	5.1	Summary of characteristics	17
62	5.2	Rated quantities and other characteristics	18
63	5.2.1	Rated voltages	18
64	5.2.2	Rated direct current (I_n)	18
65	5.2.3	Rated direct making and breaking capacity (I_m)	18
66	5.2.4	Rated residual operating direct current ($I_{\Delta n}$)	18
67	5.2.5	Rated residual non-operating direct current ($I_{\Delta no}$)	18
68	5.2.6	Rated residual direct making and breaking capacity ($I_{\Delta m}$)	18
69	5.2.7	Rated conditional short-circuit direct current (I_{nc})	19
70	5.2.8	Rated conditional residual short-circuit direct current ($I_{\Delta c}$)	19
71	5.2.9	Operating characteristics in case of residual currents with non-smooth direct currents components	19
72			
73	5.2.10	DC-RCCB type S	19
74	5.3	Standard and preferred values	19
75	5.3.1	Values of rated operational voltage (U_e)	19
76	5.3.2	Preferred values of rated direct current (I_n)	19
77	5.3.3	Standard values of rated residual operating direct current ($I_{\Delta n}$)	19
78	5.3.4	Standard value of residual non-operating direct current ($I_{\Delta no}$)	19
79	5.3.5	Minimum value of the rated residual direct making and breaking capacity ($I_{\Delta m}$)	20
80			
81	5.3.6	Preferred values of the rated conditional short-circuit current (I_{nc})	20
82	5.3.7	Preferred values of the rated conditional residual short-circuit current ($I_{\Delta c}$)	20
83			
84	5.3.8	Standard limit values of break time and non-actuating time for DC- RCCBs of type DC and DC+	20
85			
86	5.3.9	Standard minimum value of non-operating overcurrent in case of a load through a DC-RCCB with two current paths	20
87			
88	5.3.10	Standard minimum value of non-operating overcurrent in case of a single-phase load through a three-pole DC-RCCB or a DC-RCCB with three current paths	20
89			
90			
91	5.3.11	Minimum value of the direct rated making and breaking capacity (I_m)	20
92	5.3.12	Minimum value of the rated residual direct making and breaking capacity ($I_{\Delta m}$)	20
93			
94	6	Marking and other product information	20
95	6.1	Requirements for marking and other information	20
96	7	Conditions for operation in service	22
97	7.1	Preferred ranges of application, reference values of influencing quantities/factors and associated test tolerances	22
98			
99	7.2	Conditions of installation	22

100	7.3	Pollution degree.....	22
101	8	Requirements for construction and operation.....	22
102	8.1	Mechanical design.....	22
103	8.1.1	General.....	22
104	8.1.2	Mechanism.....	23
105	8.1.3	Clearances and creepage distances.....	24
106	8.1.4	Screws, current carrying parts and connections.....	25
107	8.1.5	Terminals for external conductors.....	26
108	8.2	Protection against electric shocks.....	28
109	8.3	Dielectric properties and isolating capability.....	29
110	8.4	Temperature rise.....	29
111	8.4.1	General.....	29
112	8.4.2	Temperature-rise limits.....	29
113	8.4.3	Ambient air temperature.....	29
114	8.5	Operating characteristics.....	29
115	8.5.1	General.....	29
116	8.5.2	Operation in response to DC residual current.....	29
117	8.5.3	Operation in presence of a residual current equal to and greater than	
118		$I_{\Delta n}$	30
119	8.6	Mechanical and electrical endurance.....	30
120	8.7	Performance at short-circuit and small direct currents.....	30
121	8.8	Resistance to mechanical shocks and impact.....	31
122	8.9	Resistance to heat.....	31
123	8.10	Resistance to abnormal heat and to fire.....	31
124	8.11	Test device.....	31
125	8.12	Requirements for DC-RCCBs in case of loss of supply.....	31
126	8.13	Behaviour of DC-RCCBs in case of overcurrent in the main circuit.....	32
127	8.14	Behaviour of DC-RCCBs in case of current surges caused by impulse	
128		voltages.....	32
129	8.15	Reliability.....	32
130	8.16	Electromagnetic compatibility (EMC).....	32
131	8.17	Resistance to temporary overvoltage (TOV).....	32
132	8.18	Resistance to rusting.....	33
133	8.19	Behaviour in case of making inrush current.....	33
134	8.20	Requirements for electronic components.....	33
135	8.21	Standing current in the FE under normal conditions.....	33
136	8.22	Standing current in the FE in case of DC-RCCB supplied from just one	
137		line and FE.....	33
138	9	Tests.....	33
139	9.1	General.....	33
140	9.2	Test conditions.....	34
141	9.3	Test of indelibility of marking.....	35
142	9.4	Test of reliability of screws, current-carrying parts and connections.....	35
143	9.5	Test of reliability of screw-type terminals for external copper conductors.....	36
144	9.5.1	36	
145	9.5.2	36	
146	9.5.3	36	
147	9.5.4	37	
148	9.6	Verification of protection against electric shock.....	37
149	9.7	Test of dielectric properties.....	38
150	9.7.1	Resistance to humidity.....	

151	9.7.2	Insulation resistance of the main circuit	38
152	9.7.3	Dielectric strength of the main circuit	39
153	9.7.4	Insulation resistance and dielectric strength of auxiliary circuits	40
154	9.7.5	Secondary circuit of detection transformers	41
155	9.7.6	Capability of control circuits connected to the main circuit withstanding	
156		high d.c. voltages due to insulation measurements	41
157	9.7.7	Verification of impulse withstand voltages	41
158	9.8	Test of temperature-rise	43
159	9.8.1	Ambient air temperature	43
160	9.8.2	Test procedure	43
161	9.8.3	Measurement of the temperature of parts	43
162	9.8.4	Temperature-rise of a part	43
163	9.9	Verification of the operating characteristics	43
164	9.9.1	Verification of the operating characteristics under residual current	
165		conditions	43
166	9.10	Verification of mechanical and electrical endurance	46
167	9.10.1	General test conditions	46
168	9.10.2	Test procedure	46
169	9.10.3	Condition of the DC-RCCB after test	47
170	9.11	Tests of behaviour of the DC-RCCB under short-circuit conditions	47
171	9.11.1	List of the short-circuit tests	47
172	9.11.2	Short-circuit tests	47
173	9.12	Verification of resistance to mechanical shock and impact	54
174	9.12.1	Mechanical shock	54
175	9.12.2	Mechanical impact	55
176	9.13	Test of resistance to heat	57
177	9.13.1	Test on complete DC-RCCB	57
178	9.13.2	Ball pressure test	57
179	9.14	Test of resistance to abnormal heat and to fire	59
180	9.15	Verification of the trip-free mechanism	60
181	9.15.1	General test conditions	60
182	9.15.2	Test procedure	60
183	9.15.3	Additional test procedure for DC-RCCBs according to 4.1.4 and 4.1.5	60
184	9.16	Verification of the operation of the test device at the limits of rated	
185		operational voltage	60
186	9.17	Verification of the behaviour of DC-RCCBs in case of loss of the supply	
187		voltage	61
188	9.17.1	Verification of the behaviour of DC_RCCBs classified under 4.1.4 and	
189		4.1.5	61
190	9.17.2	Verification of not opening in the event of loss of the supply voltage	
191		(DC-RCCB classified according 4.1.2 and 4.1.3)	62
192	9.18	Verification of the behaviour of DC-RCCBs in case of overcurrent in the	
193		main circuit	62
194	9.19	Verification of the behaviour of DC-RCCBs in case of current surges caused	
195		by impulse voltages	63
196	9.19.1	Current surge test for all DC-RCCBs (0,5 μ s/100 kHz ring wave test)	63
197	9.19.2	Verification of the behaviour at surge currents up to 3 000 A (8/20 μ s	
198		surge current test)	63
199	9.19.3	Test results for PCBMs of the general type	64
200	9.20	Verification of reliability	64
201	9.20.1	Climatic test	64
202	9.20.2	Test with temperature of 40 °C	66
203	9.21	Verification of withstand against ageing	66

204	9.22	Electromagnetic compatibility (EMC).....	67
205	9.22.1	Electromagnetic emission of DC-RCCBs.....	67
206	9.22.2	Electromagnetic immunity of DC-RCCBs	67
207	9.23	Test of resistance to rusting	68
208	9.24	Verification of the behaviour of the DC-RCCBs under temporary over voltage	
209		(TOV) conditions	68
210	9.24.1	General	68
211	9.24.2	TOV test for all DC-RCCBs.....	69
212	9.24.3	Additional tests for DC-RCCBs with a terminal intended to be connected	
213		to the PE	69
214	9.24.4	Verification after the tests	69
215	9.25	Requirements and tests for electronic components	69
216	9.26	Test of the maximum connecting capacity of FE terminal	69
217	9.26.1	Test procedure	69
218	9.26.2	Construction of gauges	69
219	9.27	Verification of the limitation of the standing current in the FE	69
220	9.27.1	Test circuit.....	69
221	9.27.2	Verification of the standing current in the FE under normal conditions	70
222	9.27.3	Verification of the standing current in the FE when the DC-RCCB is	
223		supplied from just one line chosen at random and FE	70
224	Annex A (normative)	Test sequence and number of samples to be submitted for	
225		certification purposes	106
226	A.1	Test sequences	106
227	A.2	Number of samples to be submitted for full test procedure	107
228	A.3	Number of samples to be submitted for simplified test procedures if	
229		submitting simultaneously a range of DC-RCCBs of the same fundamental	
230		design.....	108
231	Annex B (normative)	Determination of clearances and creepage distances	111
232	B.1	General.....	111
233	B.2	Orientation and location of a creepage distance.....	111
234	B.3	Creepage distances where more than one material is used	111
235	B.4	Creepage distances split by floating conductive part	111
236	B.5	Measurement of creepage distances and clearances	111
237		Figure B.1 – Examples of methods of measuring creepage	115
238	Annex C (normative)	Arrangement for the detection of the emission of ionized gases	
239		during short-circuit tests	116
240	Annex D (normative)	Routine tests.....	119
241	D.1	General.....	119
242	D.2	Tripping test.....	119
243	D.3	Dielectric strength test	119
244	D.4	Performance of the test device.....	119
245	Annex E (informative/normative)	Void	120
246	Annex F (informative/normative)	Void	121
247	Annex G (informative/normative)	Void	122
248	Annex H (informative)	Examples of terminal designs.....	123
249	Annex I (informative)	Correspondence between ISO and AWG copper conductors.....	126
250	Annex J (informative)	Follow-up testing program for DC-RCCBs.....	127
251	J.1	General.....	127
252	J.2	Follow-up testing program.....	127
253	J.2.1	General	127
254	J.2.2	Quarterly follow-up testing program	127

255	J.2.3	Annual follow-up testing program.....	127
256	J.2.4	Sampling procedure.....	128
257	Annex K (informative)	SCPDs for short-circuit tests	131
258	K.1	Introductory remark.....	131
259	K.2	Silver wires	131
260	K.3	Fuses	131
261	K.4	Other means	132
262	Bibliography.....		133
263			
264	Figure 1	– Standard test finger.....	71
265	Figure 2	– Examples of DC supply systems	72
266	Figure 3	– Void	73
267	Figure 4	– Test circuit for the verification of operating characteristics and trip-free mechanism for DC-RCCB	74
269	Figure 5	– Typical diagram for all short circuit tests	75
270	Figure 6	– Calibration of the test circuit in case of direct currents	76
271	Figure 7	– Detail of impedances Z and Z_1	76
272	Figure 8	– Mechanical shock test apparatus	77
273	Figure 9	– Mechanical impact test apparatus	78
274	Figure 10	– Striking element for pendulum impact test apparatus	79
275	Figure 11	– Mounting support for sample for mechanical impact test	80
276	Figure 12	– Example of mounting an unenclosed or flush-type DC-RCCB for mechanical impact test	81
278	Figure 13	– Example of mounting of panel mounting type DC-RCCB for the mechanical impact test.....	82
280	Figure 14	– Application of force for mechanical test of rail mounted DC-RCCB	83
281	Figure 15	– Ball-pressure test apparatus	84
282	Figure 16	– Current ring wave 0,5 μ s/100 kHz	85
283	Figure 17	– Test circuit for the ring wave test on RCCBs	85
284	Figure 18	– Surge current impulse 8/20 μ s.....	86
285	Figure 19	– Test circuit for the surge current test of DC-RCCBs	86
286	Figure 20	– Stabilizing period for reliability test.....	87
287	Figure 21	– Reliability test cycle	88
288	Figure 22	– Void	89
289	Figure 23	– Void	89
290	Figure 24	– Void	89
291	Figure 25	– Test apparatus for the verification of the minimum I^2t and I_p values to be withstood by the RCCB	90
293	Figure 26	– Gauges of Form A and Form B.....	91
294	Figure 27	– Diagrammatic representation for glow-wire test.....	92
295	Figure 28	– Void	92
296	Figure 29	– Void	92
297	Figure 30	– Void	92
298	Figure 31	– Test circuit for verification of the standing current in the FE	93
299	Figure C.1	– Example of test arrangement.....	117
300	Figure C.2	– Grid	118

301	Figure C.3 – Grid circuit.....	118
302	Figure H.1 – Examples of pillar terminals.....	123
303	Figure H.2 – Examples of screw terminals and stud terminals.....	124
304	Figure H.3 – Examples of saddle terminals.....	125
305	Figure H.4 – Examples of lug terminals.....	125
306		
307	Table 1 – Values of influencing quantities.....	94
308	Table 2 – Marking.....	95
309	Table 3 – Void.....	96
310	Table 4 – Void.....	96
311	Table 5 – Void.....	96
312	Table 6 – Void.....	96
313	Table 7 – Void.....	96
314	Table 8 – Void.....	96
315	Table 9 – Void.....	96
316	Table 10 – Void.....	96
317	Table 11 – Standard limit values of break time and non-actuating time for direct	
318	residual currents for type DC.....	96
319	Table 12 – Void.....	96
320	Table 13 – Tripping current limits.....	97
321	Table 14 – Void.....	97
322	Table 15 – Void.....	97
323	Table 16 – Void.....	97
324	Table 17 – Void.....	97
325	Table 18 – Void.....	97
326	Table 19 – Void.....	97
327	Table 20 – Minimum clearances and creepage distances.....	98
328	Table 21 – Test voltage of auxiliary circuits.....	99
329	Table 22 – Test voltage for verification of impulse withstand voltage.....	100
330	Table 23 – Test voltage for verifying the suitability for isolation, referred to the rated	
331	impulse withstand voltage of the DC-RCCB and the altitude where the test is carried	
332	out.....	100
333	Table 24 – Connectable cross-sections of copper conductors for screw-type terminals.....	100
334	Table 25 – Test copper conductors corresponding to the rated direct currents.....	101
335	Table 26 – Screw thread diameters and applied torques.....	101
336	Table 27 – Pulling forces.....	101
337	Table 28 – Temperature-rise values.....	102
338	Table 29 – Void.....	102
339	Table 30 – Withstand values and duration of temporary overvoltages.....	102
340	Table 31 – Void.....	102
341	Table 32 – Void.....	102
342	Table 33 – Void.....	102
343	Table 34 – Void.....	102
344	Table 35 – Tests to be made to verify the behaviour of DC-RCCBs under short-circuit	
345	conditions.....	103
346	Table 36 – Minimum values of I^2t and I_p	103

347	Table 37 – Void	104
348	Table 38 – Void	104
349	Table 39 – Void	104
350	Table 40 – Void	104
351	Table 41 – Void	104
352	Table 42 – Void	104
353	Table 43 – Void	104
354	Table 44 – Void	104
355	Table 45 – Immunity tests	104
356	Table 46 – Voltage dips and short interruptions levels	104
357	Table 47 – Preferred values of rated operational voltage (U_e).....	104
358	Table 48 – Gauges for the verification of the rated connecting capacity	
359	of the FE terminal	105
360	Table A.1 – Test sequences.....	106
361	Table A.2 – Number of samples for full test procedure	107
362	Table A.3 – Number of samples for simplified test procedure	109
363	Table J.1 – Test sequences during follow-up inspections	128
364	Table J.2 – Number of samples to be tested	130
365	Table K.1 – Indication of silver wire diameters as a function of rated currents and	
366	short-circuit currents	131
367		
368		

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS FOR HOUSEHOLD
AND SIMILAR USES FOR DC SYSTEMS****Part 2: Residual current operated circuit breakers without integral
overcurrent protection (DC-RCCBs)**

FOREWORD

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IEC 63053-2 has been prepared by subcommittee 23E: Circuit breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories. It is an International Standard.

This first edition cancels and replaces the IEC TS 63053 edition published in 2017. This edition constitutes a technical revision.

The text of this International Standard is based on the following documents:

Draft	Report on voting
23E/XX/FDIS	23E/XX/RVD

422
423 Full information on the voting for its approval can be found in the report on voting indicated in
424 the above table.

425 The language used for the development of this International Standard, is English.

426 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
427 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
428 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
429 described in greater detail at www.iec.ch/publications.

430 The committee has decided that the contents of this document will remain unchanged until the
431 stability date indicated on the IEC website under webstore.iec.ch in the data related to the
432 specific document. At this date, the document will be

- 433 • reconfirmed,
434 • withdrawn,
435 • replaced by a revised edition, or
436 • amended.
437

438

INTRODUCTION

439 In AC systems, residual current devices are used to provide protection against the risk of
440 electric shocks. In IEC 60364 (all parts), residual current devices are used for automatic
441 disconnection of supply in case of fault (see Clause 411 of IEC 60364-4-41:2005+AMD1:2017)
442 and residual current devices with rated residual operating current not exceeding 30 mA are
443 used as additional protection (see 415 of IEC 60364-4-41:2005+AMD1:2017). IEC SC 23E has
444 developed a set of standards for residual current operated protective devices intended to be
445 used in AC systems.

446 DC systems are used for applications such as photovoltaic installations, data and telecom
447 centers and electric vehicle charging systems. In addition, standards for plugs and socket-
448 outlets for ICT equipment installed in data and telecom centers have been published. Therefore,
449 a reference document for residual current devices intended to be used in DC supply systems is
450 necessary.

451 Residual current devices for DC systems may be used to provide fault protection (automatic
452 disconnection of supply according to Clause 411 of IEC 60364-4-41:2005+AMD1:2017); they
453 may also be used to provide additional protection. They provide protection against electric
454 shock downstream of the device in DC networks.

455 This document defines the operating characteristics for residual current operated protective
456 devices for DC systems. Details of how they should be installed to provide the desired level of
457 protection are specified in the various parts of the IEC 60364 series.

458 The requirements of this standard are in compliance with the Group safety Publication IEC
459 60755-1.
460

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS FOR HOUSEHOLD AND SIMILAR USES FOR DC SYSTEMS

Part 2: Residual current operated circuit breakers without integral overcurrent protection (DC-RCCBs)

1 Scope

This document gives general requirements and tests for residual current operated circuit breakers without integral overcurrent protection for household and similar uses, intended to be used in DC systems (hereafter referred to as DC-RCCBs), for rated operational voltages not exceeding 440 V DC and a rated direct current not exceeding 125 A, intended principally for protection against shock hazard.

These devices are intended to provide fault protection according to IEC 60364-4-41, the exposed conductive parts of the installation being connected to an appropriate earth electrode. In accordance with IEC 60364-4-42, DC-RCCBs with a rated residual operating current not exceeding 300 mA can also be used to provide protection against fire hazards due to a persistent earth fault current.

DC-RCCBs having a rated residual operating direct current not exceeding 80 mA, are used for fault protection and additional protection in the case of failure of the protective provisions against electric shock, in systems having a rated voltage to earth not exceeding 440 V DC.

This document applies to devices performing simultaneously the functions of detection of the residual current, of comparison of the value of this current with the residual operating value and of opening of the protected circuit when the residual current exceeds this value.

NOTE 1 The requirements for DC-RCCBs are in line with the general safety requirements of IEC 60755-1.

NOTE 2 Installation and selection rules for DC-RCCBs are given in the IEC 60364 series.

DC-RCCBs are intended to be operated by ordinary or uninstructed persons and designed not to require maintenance.

The requirements of this document apply for standard conditions. Additional requirements can be necessary for DC-RCCBs used in locations having severe environmental conditions. They are intended for use in an environment with pollution degree 2.

NOTE 3 For environments with higher pollution degrees, enclosures giving the appropriate degree of protection could be used.

NOTE 4 For DC-RCCBs having a degree of protection higher than IP20 special constructions can be required.

DC-RCCBs are suitable for isolation. They are suitable for use in TN, TT, and, under specific conditions IT systems. Single-pole DC-RCCBs with two current paths are not suitable for use in IT systems.

DC-RCCBs of the general type are resistant to unwanted tripping including the case where surge voltages (as a result of switching transients or induced by lightning) cause loading currents in the installation without occurrence of flashover.

Special precautions (e.g. surge protective devices) can be necessary when excessive overvoltages are likely to occur on the supply side (for example in the case of supply through overhead lines see IEC 60364-44 and IEC 60364-5-53).

DC-RCCBs of type S are considered to be sufficiently proof against unwanted tripping even if the surge voltage causes a flashover and a follow-on current occurs.

505 NOTE 5 Surge protective devices installed downstream of DC-RCCBs and connected in common mode can cause
506 unwanted tripping.

507 This document also applies to DC-RCCBs having more than one rated direct current, provided
508 that the means for changing from one discrete rating to another is not accessible in normal
509 service and that the rating cannot be changed without the use of a tool.

510 This document does not apply to DC-RCCBs including batteries.

511 2 Normative references

512 The following documents are referred to in the text in such a way that some or all of their content
513 constitutes requirements of this document. For dated references, only the edition cited applies.
514 For undated references, the latest edition of the referenced document (including any
515 amendments) applies.

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

517 IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety –*
518 *Protection against electric shock*

519 IEC 60755-1, *General safety requirements for residual current operated protected devices –*
520 *Part 1: Residual current operated protective devices for DC systems*

521 IEC TS 63053, *General requirements for residual current operated protective devices for DC*
522 *systems*

523 3 Terms and definitions

524 For the purposes of this document, the terms and definitions given in IEC 62873-2 and the
525 following apply.

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

528 • ISO Online browsing platform: available at <https://www.iso.org/obp>

529 • IEC Electropedia: available at <https://www.electropedia.org/>

530 3.1

531 unidirectional device

532 A protective device where it is intended that a power supply is only connected to one defined
533 set of connection terminals.

534 3.2

535 bidirectional device

536 A protective device where a power supply may be connected to either set of connection
537 terminals.

538 3.3

539 time constant

540 Rise time $\tau = L/R$ (ms) of a prospective direct current to reach a value of 0,632 times the
541 maximum peak current.

542 3.4

543 M-pole

544 Pole intended to be connected to the mid-point conductor.

3.5 mid-point conductor

Conductor electrically connected to the mid-point and capable of contributing to the distribution of electric energy.

3.6 mid-point

Common point between two symmetrical circuit elements the opposite ends of which are electrically connected to different line conductors of the same circuit.

4 Classification

4.1 According to the supply conditions

4.1.1 DC-RCCB operating correctly on the occurrence of residual current

- within the voltage range $1,1 U_e$ and zero volt; and
- with any number of supply conductors connected.

The DC-RCCB does not open automatically in the case of loss of supply.

4.1.2 RCCB with 2 or 4 current paths operating correctly on the occurrence of residual current within the voltage range of $1,1 U_e$ and 90 V

The DC-RCCB does not open automatically in the case of loss of supply.

4.1.3 RCCB according to 4.1.2 fitted with a functional earth (FE) and able to continue to provide protection when supplied from just one line and FE

4.1.3.1 Does not open automatically in the case of loss of supply and continues to provide residual current protection in the case of supply from just one line and FE

4.1.3.2 Does not open automatically in the case of loss of one line and provides protection by opening automatically if supplied from just one line and FE

4.1.4 RCCB operating correctly on the occurrence of residual current within the voltage range $1,1 U_e$ and U_x

The device opens automatically, with or without delay, in the event of a supply voltage drop to a value less than U_x .

4.1.5 RCCB according to 4.1.4, however reclosing automatically after restoration of the supply voltage

4.2 According to the possibility of adjusting the residual operating current

4.2.1 DC-RCCB with a single value of rated residual operating current

4.2.2 DC-RCCB with multiple settings of residual operating current by fixed steps

4.3 According to behaviour of residual direct current type

4.3.1 DC-RCCB Type DC for smooth direct current

4.3.2 DC-RCCB Type DC+ for non-smooth direct current

Type DC+ also covers Type DC.

NOTE Type DC+ is under study

4.4 According to time-delay (in presence of a residual current)**4.4.1 DC-RCCB without time-delay: type for general use****4.4.2 DC-RCCB with time-delay: type S with time-delay of 0,06 s for selectivity****4.5 According to the protection against external influences****4.5.1 Enclosed-type DC-RCCB (not requiring an appropriate enclosure)****4.5.2 Unenclosed-type DC-RCCB (for use with an appropriate enclosure)****4.6 According to the method of mounting****4.6.1 Surface-type DC-RCCB****4.6.2 Flush-type DC-RCCB****4.6.3 Panel board type DC-RCCB, also referred to as distribution board type**

NOTE These types can be intended to be mounted on rails.

4.7 According to the method of connection**4.7.1 DC-RCCB, the electrical connections of which are not associated with the mechanical mounting****4.7.2 DC-RCCB, the electrical connections of which are associated with the mechanical mounting**

NOTE Examples of this type are:

- plug-in type.
- bolt-on type.
- screw-in type.

Some DC-RCCBs can be of the plug-in type or bolt-on type on the supply side only, the load terminals being usually suitable for wiring connection.

4.8 According to the type of terminals**4.8.1 DC-RCCB with screw-type terminals for external copper conductors****4.8.2 DC-RCCB with screwless type terminals for external copper conductors**

NOTE The requirements for DC-RCCBs equipped with these types of terminals are given in IEC 62873-3-1.

4.8.3 DC-RCCB with flat quick-connect terminals for external copper conductors

NOTE The requirements for DC-RCCBs equipped with these types of terminals are given in IEC 62873-3-2.

4.9 According to the number of poles and current paths**4.9.1 Single-pole DC-RCCB with two current paths**

NOTE In this case, the M-path does not contain any switching contact.

4.9.2 Two-pole DC-RCCB**4.9.3 Two-pole DC-RCCB with three current paths**

NOTE In this case, the M-path does not contain any switching contact.

4.9.4 Three-pole DC-RCCB**4.10 According to the current direction through the poles****4.10.1 Polarised DC-RCCB****4.10.2 Non-polarised DC-RCCB****4.11 According to the supply side of the device (directionality)****4.11.1 DC-RCCB to be supplied on one specific side (uni-directional)**

Uni-directional DC-RCCB is intended to be supplied from one defined set of connection terminals only.

4.11.2 DC-RCCB to be supplied on any side (bi-directional)

Bi-directional DC-RCCB is intended to be supplied from any set of connection terminals.

NOTE: A bi-directional DC-RCCB can be polarized.

5 Characteristics of DC-RCCBs**5.1 Summary of characteristics**

Unless otherwise stated, when referring to voltages and currents, they shall be read as direct current quantities.

The characteristics of an DC-RCCB shall be stated in the following terms:

- rated voltages (see 5.2.1);
- rated direct current I_n (see 5.2.2);
- rated direct making and breaking capacity I_m (see 5.2.3);
- rated residual operating direct current $I_{\Delta n}$ (see 5.2.4);
- rated residual non-operating direct current $I_{\Delta no}$ (see 5.2.5);
- rated residual direct making and breaking capacity $I_{\Delta m}$ (see 5.2.6);
- time-delay, if applicable (see 4.4);
- operating characteristics (see 5.2.9);
- rated conditional short-circuit direct current I_{nc} (see 5.2.7);
- rated conditional residual short-circuit direct current $I_{\Delta c}$ (see 5.3.7);
- degree of protection (see IEC 60529).

5.2 Rated quantities and other characteristics

5.2.1 Rated voltages

5.2.1.1 Rated operational voltage (U_e)

The rated operational voltage (hereafter referred to as "rated voltage") of an DC-RCCB is the value of voltage, assigned by the manufacturer, to which its performance is referred.

NOTE The same DC-RCCB may be assigned a number of rated voltages and associated rated short-circuit capacities.

5.2.1.2 Rated insulation voltage (U_i)

Unless otherwise stated, the rated insulation voltage is assumed to be equal to the highest rated operational voltage assigned to the DC-RCCB.

Where the rated insulation voltage assigned by the manufacturer exceeds the highest rated operational voltage of the DC-RCCB, the dielectric test voltages and creepage distances shall be chosen for that rated insulation voltage in accordance with IEC 60664-1.

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of an DC-RCCB shall be equal to 4 kV.

5.2.1.4 Minimum operating voltage (U_x)

The minimum operating voltage, where applicable, as declared by the manufacturer for DC-RCCBs.

5.2.2 Rated direct current (I_n)

A current assigned by the manufacturer as the current which the DC-RCCB can carry uninterrupted duty.

5.2.3 Rated direct making and breaking capacity (I_m)

The prospective direct current, assigned by the manufacturer, which an DC-RCCB can make, carry and break under specified conditions.

5.2.4 Rated residual operating direct current ($I_{\Delta n}$)

The value of residual operating direct current, assigned by the manufacturer, at which the DC-RCCB shall operate under specified conditions.

For an DC-RCCB having multiple settings of residual operating direct current, the highest setting is used to designate it.

DC-RCCBs with continuously adjustable settings are not allowed.

5.2.5 Rated residual non-operating direct current ($I_{\Delta no}$)

The value of residual non-operating direct current, assigned by the manufacturer, at which the DC-RCCB does not operate under specified conditions.

5.2.6 Rated residual direct making and breaking capacity ($I_{\Delta m}$)

The value of the residual prospective direct current, assigned by the manufacturer, which an DC-RCCB can make, carry and break under specified conditions.

5.2.7 Rated conditional short-circuit direct current (I_{nc})

The value of the prospective direct current, assigned by the manufacturer, which an DC-RCCB, protected by a specified SCPD, can withstand under specified conditions without undergoing alterations impairing its functions.

5.2.8 Rated conditional residual short-circuit direct current ($I_{\Delta c}$)

The value of the residual prospective direct current, assigned by the manufacturer, which an DC-RCCB, protected by a specified SCPD, can withstand under specified conditions without undergoing alterations impairing its functions.

5.2.9 Operating characteristics in case of residual currents with non-smooth direct currents components**5.2.9.1 DC-RCCB type DC**

A DC-RCCB for which tripping is ensured for residual smooth direct currents, whether suddenly applied or slowly rising.

5.2.9.2 DC-RCCB type DC+

A DC-RCCB for which tripping is ensured for residual smooth direct currents and residual non-smooth direct currents, whether suddenly applied or slowly rising.

NOTE Type DC+ is under study

5.2.10 DC-RCCB type S

A time-delay DC-RCCB which complies with the relevant part of Table 2, if applicable.

5.3 Standard and preferred values**5.3.1 Values of rated operational voltage (U_e)**

Preferred values of rated voltage are given in Table 47:

5.3.2 Preferred values of rated direct current (I_n)

Preferred values of rated direct currents are:

10 A – 13 A – 16 A – 20 A – 25 A – 32 A – 40 A – 63 A – 80 A – 100 A – 125 A

5.3.3 Standard values of rated residual operating direct current ($I_{\Delta n}$)

Standard values of rated residual operating direct current are:

0,02 A – 0,08 A – 0,3 A – 0,6 A – 1 A – 2 A – 3 A – 5 A – 10 A – 20 A – 30 A

NOTE 1 The value of 80 mA was the result of a calculation based on the content of clause 6 of IEC 60479-1:2018.

NOTE 2 In Austria the value of 80 mA is considered as provisional until a broader and more solid set of data than the actual basis of the IEC 60479 series is available for DC.

5.3.4 Standard value of residual non-operating direct current ($I_{\Delta no}$)

The standard value of residual non-operating direct current is $0,5 I_{\Delta n}$.

5.3.5 Minimum value of the rated residual direct making and breaking capacity ($I_{\Delta m}$)

The minimum value of the rated residual direct making and breaking capacity ($I_{\Delta m}$) is $10 I_n$ or 500 A, whichever is the greater.

5.3.6 Preferred values of the rated conditional short-circuit current (I_{nc})

The preferred values of the rated conditional short-circuit current for DC-RCCBs without integral short-circuit protection are:

1 500 A – 3 000 A – 4 500 A – 6 000 A – 10 000 A

5.3.7 Preferred values of the rated conditional residual short-circuit current ($I_{\Delta c}$)

The preferred values of the rated conditional short-circuit current for DC-RCCBs without integral short-circuit protection are:

1 500 A – 3 000 A – 4 500 A – 6 000 A – 10 000 A

5.3.8 Standard limit values of break time and non-actuating time for DC-RCCBs of type DC and DC+**5.3.8.1 Standard limit values of break time and non-actuating time for direct residual currents of type DC**

Standard limit values are indicated in Table 11.

5.3.8.2 Standard limit values of break time and non-actuating time for direct residual currents of type DC+

Under study.

5.3.9 Standard minimum value of non-operating overcurrent in case of a load through a DC-RCCB with two current paths

The standard minimum value of the non-operating direct current is $6 I_n$.

5.3.10 Standard minimum value of non-operating overcurrent in case of a single-phase load through a three-pole DC-RCCB or a DC-RCCB with three current paths

The standard minimum value of the non-operating overcurrent in case of a single-phase load through a three-pole DC-RCCB is $6 I_n$.

5.3.11 Minimum value of the direct rated making and breaking capacity (I_m)

The minimum value of the direct rated making and breaking capacity I_m is $10 I_n$ or 500 A, whichever is the greater.

5.3.12 Minimum value of the rated residual direct making and breaking capacity ($I_{\Delta m}$)

The minimum value of the rated residual direct making and breaking capacity $I_{\Delta m}$ is $10 I_n$ or 500 A, whichever is the greater.

6 Marking and other product information**6.1 Requirements for marking and other information**

Each DC-RCCB shall be marked according to Table 2, in a durable manner.

The suitability for isolation, which is provided by all DC-RCCBs of this standard, may be indicated by the symbol  on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions.

NOTE In Australia, this marking on the circuit-breaker is mandatory but is not required to be visible after installation.

When the symbol is used on its own (i.e. not in a wiring diagram), combination with symbols of other functions is not allowed.

If a degree of protection higher than IP20 according to IEC 60529 is marked on the device, it shall comply with it, whichever the method of installation. If the higher degree of protection is obtained only by a specific method of installation and/or with the use of specific accessories (e.g. terminal covers, enclosures, etc.), this shall be specified in the manufacturer's literature.

For DC-RCCBs classified according to 4.1.4 and 4.1.5 and opening with delay in case of failure of the line voltage, the manufacturer shall state in its documentation the range of such delay.

The manufacturer shall state the Joule integral I^2t and the peak current I_p withstand capabilities of the DC-RCCB. Where these are not stated, minimum values as given in Table 36 apply.

The manufacturer shall give the type designation or catalogue number of one or more suitable SCPD(s) in its catalogue.

DC-RCCBs other than those operated by means of push-button, the open position shall be indicated by the symbol "O" and the closed position by the symbol "|" (a short straight line). Additional national symbols are allowed for this indication. Provisionally, the use of national indications only is allowed. These indications shall be readily visible when the DC-RCCB is installed.

For DC-RCCBs operated by means of two push-buttons, the push-button designed for the opening operation only shall be red and/or be marked with the symbol "O".

RED shall not be used for any other push-button of the DC-RCCB.

If a push-button is used for closing the contacts and is evidently identified as such, its depressed position is sufficient to indicate the closed position.

If a single push-button is used for closing and opening the contacts and is identified as such, the button remaining in its depressed position is sufficient to indicate the closed position. On the other hand, if the button does not remain depressed, an additional means indicating the position of the contacts shall be provided.

Terminals intended for the protective conductor, if any, shall be indicated by the symbol  (IEC 60417-5019:2006-08).

Terminals intended for the functional earth conductor (FE), if any, shall be indicated by the letters "FE".

Universal terminals:

- no marking.

Non-universal terminals:

- terminals declared for rigid-solid conductors shall be marked by the letters "sol";
- terminals declared for rigid (solid and stranded) conductors shall be marked by the letter "r";
- terminals declared for flexible conductors shall be marked by the letter "f".

The marking of non-universal terminals should appear on the device or, if the space available is not sufficient, on the smallest package unit or in technical information.

Marking shall be indelible, easily legible and not be placed on screws, washers or other removable parts.

Compliance is checked by inspection and by the test of 9.3.

7 Conditions for operation in service

7.1 Preferred ranges of application, reference values of influencing quantities/factors and associated test tolerances

DC-RCCBs complying with this document shall be capable of operating under the standard conditions shown in Table 1.

7.2 Conditions of installation

DC-RCCBs shall be installed in accordance with the manufacturer's instructions.

7.3 Pollution degree

DC-RCCBs are intended for an environment with pollution degree 2, i.e. normally, only non-conductive pollution occurs. However, occasionally, temporary conductivity caused by condensation may be expected.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

DC-RCCBs shall be designed and constructed so that, in normal use, their operation is safe and without danger to the user or to the environment.

The residual current detection and the residual current release shall be located between the incoming and outgoing terminals of the DC-RCCB.

It shall not be possible to alter the operating characteristics of the DC-RCCB by means of external interventions other than those specifically intended for changing the setting of the residual operating current or of the time delay.

Changing from one setting to another shall not be possible without a tool. It shall not be possible to disable or inhibit the DC-RCCB function by any means.

NOTE In Austria, Australia, Germany, Denmark, Italy, the UK, Ireland and Switzerland, multiple settings are not allowed.

DC-RCCBs with continuously adjustable settings are not allowed.

Provisions for remote tripping of the DC-RCCB, if any, shall:

- not cause any current to the PE;
- not cause any fault voltage when actuated, and
- not impair the isolation function of the DC-RCCB.

DC-RCCBs shall not be operated by introduction of an external connection for the purpose of intentionally creating a residual current to trip the DC-RCCB.

828 NOTE 1 This does not preclude the use of an DC-RCCB with a functional earth connection.

829 NOTE 2 This does not preclude the use of a test instrument

830 NOTE 3 This requirement does not apply in Japan

831 **8.1.2 Mechanism**

832 All poles of multipole DC-RCCBs shall be mechanically coupled so that all poles, except the
833 mid-point M-pole, if any, make and break substantially together, whether operated manually or
834 automatically.

835 The mid-point M-pole of three-pole DC-RCCBs shall not close after and shall not open before
836 the other poles.

837 *Compliance is checked by inspection and by manual tests, using any appropriate means*
838 *(example: indicator lights, oscilloscope, etc.).*

839 DC-RCCBs shall have a trip-free mechanism.

840 It shall be possible to switch the DC-RCCB ON and OFF by hand. For plug-in DC-RCCBs without
841 an operating handle, this requirement is not considered to be met by the fact that the DC-RCCB
842 can be removed from its base.

843 DC-RCCBs shall be so constructed that the moving contacts can come to rest only in the closed
844 position or in the open position, even when the operating means is released in an intermediate
845 position.

846 DC-RCCBs shall provide in the open position an isolation distance in accordance with the
847 requirements necessary to satisfy the isolating function (see 8.3).

848 Indication of the position of the main contacts shall be provided by one or both of the following
849 means:

- 850 – the position of the actuator (this being preferred); or
- 851 – a separate mechanical indicator.

852 If a separate mechanical indicator is used to indicate the position of the main contacts, this
853 shall show the colour red for the closed position and the colour green for the open position.

854 NOTE In the US, the colours red and green are not used for contact position indication.

855 The means of indication of the contact position shall be reliable.

856 DC-RCCBs shall be designed so that the actuator, front plate or cover can only be correctly
857 fitted in a manner which ensures correct indication of the contact position.

858 When means are provided or specified by the manufacturer to lock the operating means in the
859 open position, locking in that position shall only be possible when the main contacts are in the
860 open position.

861 Locking of the operating means in the closed position is permitted.

862 *Compliance is checked by inspection, taking into account the instructions of the manufacturer.*

863 Where the operating means is used to indicate the position of the contacts, the operating
864 means, when released, shall automatically take up the position corresponding to that of the
865 moving contacts; in this case, the operating means shall have two distinct rest positions
866 corresponding to the position of the contacts but, for automatic opening, a third distinct position
867 of the operating means may be provided, in which case it shall be necessary to reset the DC-
868 RCCB manually before reclosing is possible.

869 When an indicator light is used, this shall be lit when the DC-RCCB is in the closed position
870 and be of bright colour. The indicator light shall not be the only means to indicate the closed
871 position.

872 The action of the mechanism shall not be influenced by the position of enclosures or covers
873 and shall be independent of any removable part.

874 A cover sealed in position by the manufacturer is considered to be a non-removable part.

875 If the cover is used as a guiding means for push-buttons, it shall not be possible to remove the
876 buttons from the outside of the DC-RCCB.

877 Operating means shall be securely fixed on their shafts and it shall not be possible to remove
878 them without the aid of a tool.

879 Operating means directly fixed to covers are allowed. If the operating means has an "up-down"
880 movement, when the DC-RCCB is mounted as in normal use, the contacts shall be closed by
881 the up movement.

882 *Compliance is checked by inspection, by manual test and, for the trip-free mechanism, by the*
883 *test of 9.11 and 9.15.*

884 **8.1.3 Clearances and creepage distances**

885 **8.1.3.1 General**

886 The minimum required clearances and creepage distances are given in Table 20 which is based
887 on the DC-RCCB being designed for operating in an environment with pollution degree 2.

888 Parts of PCBs connected to the live parts protected against pollution by the use of a type 2
889 protection according to IEC 60664-3 are exempt from this verification.

890 The insulating materials are classified into material groups on the basis of their comparative
891 tracking index (CTI) according to IEC 60664-1.

892 NOTE 1 The comparative tracking index (CTI) is declared by the manufacturer on the basis of tests carried out on
893 the insulating material.

894 NOTE 2 Information on the requirements for design of solid insulation is provided in IEC 60664-1.

895 For clearances on printed wiring material, Footnote c in Table F.2 of IEC 60664-1:2020 applies:
896 "For printed wiring material, the values for pollution degree 1 apply except that the value shall
897 not be less than 0,04 mm, as specified in Table F.5 of IEC 60664-1:2020. A protection by means
898 of a solder resist of high quality is the minimum requirement to allow this clearance reduction".

899 All measurements required in this Subclause 8.1.3 are carried out in Test Sequence A on one
900 sample. Tests according to 9.7 are carried out in Test Sequence B on three samples.

901 **8.1.3.2 Clearances**

902 *Compliance for item 1 in Table 20 is checked by measurement and by the tests of 9.7.7.3. The*
903 *test is carried out with samples not submitted to the humidity treatment described in 9.7.1.*

904 *Compliance for items 2 and 4 in Table 20 is checked by measurement and, if the clearances*
905 *are reduced, by the tests of 9.7.7.2.*

906 The clearances of items 2 and 4 in Table 20 (except for accessible surfaces after installation,
907 see below) may be reduced provided that the measured clearances are not shorter than the
908 minimum allowed in IEC 60664-1 for homogenous field conditions. In this case, compliance for
909 items 2 and 4 is always checked by the test of 9.7.7.2.

910 Accessible surface after installation means any surface accessible by the user when the DC-
911 RCCB is installed according to the manufacturer's instructions. The test finger can be applied
912 to determine whether a surface is accessible or not.

913 *Compliance for item 3 in Table 20 is checked by measurement.*

914 **8.1.3.3 Creepage distances**

915 *Compliance for items 1, 2, 3 and 4 in Table 20 is checked by measurement.*

916 **8.1.3.4 Solid insulation**

917 *Compliance is checked by the tests according to 9.7.2, 9.7.3, 9.7.4, 9.7.5 and 9.7.7 as*
918 *applicable.*

919 **8.1.3.5 Additional requirements for control circuits connected to the main circuit**

920 *Compliance is checked by the test of 9.7.6.*

921 **8.1.4 Screws, current carrying parts and connections**

922 **8.1.4.1 Connections**

923 Connections, whether electrical or mechanical, shall withstand the stresses occurring in normal
924 use.

925 Screws operated when mounting the DC-RCCB during installation shall not be of the
926 thread-cutting type.

927 Screws (or nuts) which are operated when mounting the DC-RCCB include screws for fixing
928 covers or cover-plates, but not connecting means for screwed conduits and for fixing the base
929 of a DC-RCCB.

930 NOTE Screwed connections are considered to be checked by the tests of 9.8, 9.11, 9.12, 9.13 and 9.21.

931 *Compliance is checked by inspection, by manual test and by the test of 9.4.*

932 **8.1.4.2 Screws in engagement with a thread of insulating material**

933 For screws in engagement with a thread of insulating material and which are operated when
934 mounting the DC-RCCB during installation, correct introduction of the screw into the screw hole
935 or nut shall be ensured.

936 *Compliance is checked by inspection and by manual test.*

937 The requirement with regard to correct introduction is met if introduction of the screw in a
938 slanting manner is prevented, for example by guiding the screw by the part to be fixed, by a
939 recess in the female thread or by the use of a screw with the leading thread removed.

940 **8.1.4.3 Electrical connections**

941 Electrical connections shall be so designed that contact pressure is not transmitted through
942 insulating material other than ceramic, pure mica or other material with characteristics no less
943 suitable, unless there is sufficient resilience in the metallic parts to compensate for any possible
944 shrinkage or yielding of the insulating material.

945 *Compliance is checked by inspection.*

946 NOTE The suitability of the material is considered in respect of the stability of the dimensions.

8.1.4.4 Current-carrying parts

Current-carrying parts and parts intended for protective conductors, if any, shall be made of a metal having, under the conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate for their intended use.

Examples of suitable materials are given below:

- copper;
- an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts;
- other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

If using ferrous alloys or suitably coated ferrous alloys, compliance to resistance to corrosion is checked by a test of resistance to rusting according to 9.23.

The requirements of this Subclause 8.1.4.4 do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, electronic components, printed circuit boards, nor to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

8.1.5 Terminals for external conductors

8.1.5.1

Terminals for external conductors shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is maintained permanently.

Connection arrangements intended for busbar connection are admissible, provided they are not used for the connection of cables.

The terminals shall be readily accessible under the intended conditions of use.

Compliance is checked by inspection, by the tests of 9.5 for screw-type terminals, by specific tests for plug-in or bolt-on DC-RCCBs included in this document, or by the tests of IEC 62873-3-1, IEC 62873-3-2, as relevant for the type of connection.

8.1.5.2

DC-RCCBs shall be provided with one of the following:

- terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 24; or

NOTE Examples of possible designs of screw-type terminals are given in Annex H.

- screwless type terminals for copper conductors according to IEC 62873-3-1; or
- flat quick-connect terminals for copper conductors according to IEC 62973-3-2.

Compliance for terminals according to the first indent is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-section as specified in Table 24.

8.1.5.3

The means for clamping the conductors in the terminals shall not serve to fix any other component, although they may hold the terminals in place or prevent them from turning.

Compliance is checked by inspection.

8.1.5.4

Terminals for rated direct currents up to and including 32 A shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection.

NOTE The term "special preparation" covers soldering of wire of the conductor, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a flexible conductor to consolidate the end.

8.1.5.5

Terminals shall have adequate mechanical strength for the intended use.

Screws and nuts for clamping the conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.2.

8.1.5.6

Terminals shall be so designed that they clamp the conductor without undue damage to the conductor.

Compliance is checked by inspection and by the test of 9.5.3.

8.1.5.7

Terminals shall be so designed that they clamp the conductor reliably and between metal surfaces.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.2.

8.1.5.8

Terminals shall be so designed or positioned that neither a rigid solid conductor nor a wire of a stranded conductor can slip out while the clamping screws or nuts are tightened.

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.4.

8.1.5.9

Terminals shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, their fixings do not work loose.

These requirements do not imply that the terminals shall be so designed that their rotation or displacement is prevented, but any movement shall be sufficiently limited so as to prevent non-compliance with the requirements of this document.

The use of sealing compound or resin is considered to be sufficient for preventing a terminal from working loose, provided that

- the sealing compound or resin is not subject to stress during normal use;
- the effectiveness of the sealing compound or resin is not impaired by temperatures attained by the terminal under the most unfavourable conditions specified in this document.

Compliance is checked by inspection, by measurement and by the test of 9.4.

1023 **8.1.5.10**

1024 Clamping screws or nuts of terminals intended for the connection of protective conductors shall
1025 be adequately secured against accidental loosening and it shall not be possible to unclamp
1026 them without the use of a tool.

1027 *Compliance is checked by manual test.*

1028 In general, the designs of terminals of which examples are shown in Annex H provide sufficient
1029 resilience to comply with this requirement; for other designs special provisions, such as the use
1030 of an adequately resilient part which is not likely to be removed inadvertently, may be
1031 necessary.

1032 **8.1.5.11**

1033 Screws and nuts of terminals intended for the connection of external conductors shall be in
1034 engagement with a metal thread and the screws shall not be of the thread cutting type.

1035 *Compliance is checked by inspection.*

1036 **8.1.5.12**

1037 This Subclause applies to DC-RCCBs classified according to 4.1.3.

1038 The rated connecting capacity of the FE terminal shall not exceed 2,5 mm² and it shall not be
1039 possible to connect a wire greater than 2,5 mm².

1040 The DC-RCCB FE-wire shall have a cross-section of at least 0,75 mm².

1041 *Compliance is checked by the tests of 9.26, inspection and measurement.*

1042 **8.2 Protection against electric shocks**

1043 DC-RCCBs shall be so designed that, when they are mounted and wired as for normal use, live
1044 parts are not accessible.

1045 NOTE The term "normal use" implies that DC-RCCBs be installed according to the manufacturer's instructions.

1046 A part is considered to be "accessible" if it can be touched by the standard test finger (Figure 1).

1047 For DC-RCCBs other than those of the plug-in type, external parts, other than screws or other
1048 means for fixing covers and labels, which are accessible when the DC-RCCBs are mounted and
1049 wired as in normal use, shall either be of insulating material, or be lined throughout with
1050 insulating material.

1051 Linings shall be fixed in such a way that they are not likely to be lost during installation of the
1052 DC-RCCBs. They shall have adequate thickness and mechanical strength and shall provide
1053 adequate protection at places where sharp edges occur.

1054 Inlet openings for cables or conduits shall either be of insulating material or be provided with
1055 bushings or similar devices of insulating material. Such devices shall be reliably fixed and shall
1056 have adequate mechanical strength.

1057 For plug-in DC-RCCBs, external parts other than screws or other means for fixing covers, which
1058 are accessible for normal use, shall be of insulating material.

1059 Metallic operating means shall be insulated from live parts and their conductive parts which
1060 otherwise would be "exposed conductive parts" shall be covered by insulating material, with the
1061 exception of means for coupling insulated operating means of several poles.

1062 Metal parts of the mechanism shall not be accessible. In addition, they shall be insulated from
1063 accessible metal parts, from metal frames supporting the base of flush-type DC-RCCBs, from
1064 screws or other means for fixing the base to its support and from metal plates used as support.

1065 It shall be possible to replace plug-in DC-RCCBs easily without touching live parts.

1066 Lacquer and enamel are not considered to provide adequate insulation for the purpose of this
1067 subclause.

1068 *Compliance is checked by inspection and by the test of 9.6.*

1069 **8.3 Dielectric properties and isolating capability**

1070 DC-RCCBs shall have adequate dielectric properties.

1071 Control circuits connected to the main circuit shall not be damaged by high DC voltage due to
1072 insulation measurements which are normally carried out after DC-RCCBs are installed.

1073 DC-RCCBs shall ensure isolation.

1074 *Compliance is checked by the tests of 9.7.*

1075 **8.4 Temperature rise**

1076 **8.4.1 General**

1077 The DC-RCCB shall not suffer damage impairing its functions and its safe use taking into
1078 account the ambient air temperature at which they are intended to be used.

1079 *Compliance is checked by the tests of 9.8.*

1080 **8.4.2 Temperature-rise limits**

1081 The temperature-rises of the parts of a DC-RCCB specified in Table 28, measured under the
1082 conditions specified in 9.8.2, shall not exceed the limiting values stated in Table 28.

1083 **8.4.3 Ambient air temperature**

1084 The temperature-rise limits given in Table 28 are applicable only if the ambient air temperature
1085 remains between the limits given in Table 1.

1086 **8.5 Operating characteristics**

1087 **8.5.1 General**

1088 DC-RCCBs shall operate according to the requirements of the following subclauses, as
1089 applicable.

1090 **8.5.2 Operation in response to DC residual current**

1091 **8.5.2.1 General**

1092 The tripping characteristic of DC-RCCBs shall ensure adequate protection against residual
1093 current without premature operation.

1094 The tests shall verify the operation of the DC-RCCBs within their voltage range according to
1095 the classification.

1096 *Compliance is checked by the tests of 9.9.*

8.5.2.2 Residual smooth direct currents

DC-RCCBs shall operate in response to a steady increase of residual smooth direct current within specified limits of the rated residual non-operating direct current ($I_{\Delta no}$) and the operating direct current ($I_{\Delta n}$) in accordance with Table 13.

The limits shall be independent of the polarity of the smooth direct residual current.

8.5.2.3 Residual non-smooth direct currents

NOTE Under study

8.5.3 Operation in presence of a residual current equal to and greater than $I_{\Delta n}$ **8.5.3.1 DC-RCCBs without time-delay**

The operation of DC-RCCBs to a suddenly applied residual current shall be in accordance with Table 11 for general type and whatever the polarity, if any.

Compliance is checked by the tests of 9.9.

8.5.3.2 DC-RCCBs with time-delay

The operation and non-operation of DC-RCCBs to a suddenly applied residual current shall be in accordance with Table 11 for S type and whatever the polarity, if any.

Compliance is checked by the tests of 9.9.

8.6 Mechanical and electrical endurance

DC-RCCBs shall be capable of performing an adequate number of mechanical and electrical operations.

Compliance is checked by the test of 9.10.

8.7 Performance at short-circuit and small direct currents

DC-RCCBs shall be capable of performing a specified number of short-circuit operations during which they shall neither endanger the operator nor initiate a flashover between live conductive parts or between live conductive parts and earth.

For coordination with short circuit protective devices (SCPDs), DC-RCCBs shall be protected against short-circuits by means of circuit-breakers or fuses complying with their relevant standards.

The association of a short-circuit protective device with an DC-RCCB is intended to ensure adequate protection of the residual current device from the effects of short-circuit currents.

The short-circuit protective device shall be selected according to the following characteristics in line with the characteristics of the DC-RCCB:

- a) maximum let-through I^2t ;
- a) maximum value of let-through peak current I_p .

The rating and type of SCPD shall be the same for 5.2.7 and 5.2.8.

Coordination between DC-RCCBs and the SCPD shall be verified under the general conditions of 9.11.2.1 by means of the tests described in 9.11.2.4 which are designed to verify that there is an adequate protection of the DC-RCCBs against short-circuit currents up to the conditional short-circuit direct current I_{nc} and up to the conditional residual short-circuit direct current $I_{\Delta n}$.

1135 *Compliance is checked by the tests of 9.1.1.*

1136 **8.8 Resistance to mechanical shocks and impact**

1137 DC-RCCBs shall have adequate mechanical behaviour so as to withstand the stresses imposed
1138 during installation and use.

1139 *Compliance is checked by the test of 9.12.*

1140 **8.9 Resistance to heat**

1141 DC-RCCBs shall be sufficiently resistant to heat.

1142 *Compliance is checked by the test of 9.13.*

1143 **8.10 Resistance to abnormal heat and to fire**

1144 External parts of DC-RCCBs made of insulating material shall not be liable to ignite and to
1145 spread fire if current-carrying parts in their vicinity, under fault or overload conditions, attain a
1146 high temperature. The resistance to abnormal heat and to fire of the other parts made of
1147 insulating material is considered as checked by the other tests of this document.

1148 *Compliance is checked by inspection and by the test of 9.14.*

1149 **8.11 Test device**

1150 DC-RCCBs shall be provided with a test device to simulate the passing through the detecting
1151 device of a residual current in order to allow a periodic testing of the ability of the residual
1152 current device to operate.

1153 NOTE The test device is intended to check the tripping function, not the value at which this function is effective with
1154 respect to the rated residual operating current and the break times.

1155 The ampere-turns produced when operating the test device of a DC-RCCB supplied at rated
1156 operational voltage or at the highest value of the voltage range, if applicable, shall not exceed
1157 2,5 times the ampere-turns produced, when a residual direct current equal to $I_{\Delta n}$ is passed
1158 through one of the poles of the DC-RCCB.

1159 In the case of DC-RCCBs having several settings of residual operating current, the lowest
1160 setting for which the DC-RCCBs have been designed shall be used.

1161 The protective conductor of the installation shall not become live when the test device is
1162 operated.

1163 It shall not be possible to energize the circuit on the load side by operating the test device when
1164 the DC-RCCB is in the open position and connected as in normal use.

1165 The test device shall not be the sole means of performing the opening operation and is not
1166 intended to be used for this function.

1167 *Compliance is checked by inspection and by the tests of 9.16.*

1168 **8.12 Requirements for DC-RCCBs in case of loss of supply**

1169 DC-RCCBs shall operate according to their supply conditions classification (see 4.1).

1170 DC-RCCBs classified according to 4.9.3 or 4.9.4 shall operate also in case of loss of one supply
1171 conductor, line or mid-point M.

1172 For DC-RCCBs classified according to 4.1.4 and 4.1.5, U_x shall not be greater than 0,85 U_e (or,
1173 if relevant, 0,85 times the minimum value of the range of rated voltages).

1174 DC-RCCBs classified according to 4.1.5 shall not reclose automatically after opening due to a
1175 residual current.

1176 *Compliance is checked by the test of 9.17.*

1177 **8.13 Behaviour of DC-RCCBs in case of overcurrent in the main circuit**

1178 DC-RCCBs without integral overcurrent protection shall not operate under specified conditions
1179 of overcurrents.

1180 *Compliance is checked by the test of 9.18.*

1181 **8.14 Behaviour of DC-RCCBs in case of current surges caused by impulse voltages**

1182 DC-RCCBs shall adequately withstand the current surges to earth:

1183 - due to the loading of the capacitances of the installation, or

1184 - due to surges of atmospheric origin.

1185 DC-RCCBs of type S shall withstand and shall have adequate resistance against unwanted
1186 tripping in the event of surge current to earth:

1187 - due to the loading of the capacitances of the installation, or

1188 - due to surges of atmospheric origin, or

1189 - due to flashovers causing follow currents.

1190 *Compliance is checked by the test of 9.19.*

1191 **8.15 Reliability**

1192 DC-RCCBs shall operate reliably even after long service, taking into account the ageing of their
1193 components.

1194 *Compliance is checked by the tests of 9.20 and 9.21.*

1195 **8.16 Electromagnetic compatibility (EMC)**

1196 DC-RCCBs shall operate reliably, even in presence of electromagnetic disturbances, and shall
1197 comply with relevant EMC requirements.

1198 In addition, the operating characteristics shall not be affected by high frequency ripple. This
1199 requirement is verified with the test 9.22.2.9 for ripple immunity.

1200 *Compliance is checked by the tests of 9.22.*

1201 **8.17 Resistance to temporary overvoltage (TOV)**

1202 DC-RCCBs shall adequately withstand temporary overvoltages due to various phenomena.

1203 Withstand values of overvoltage and duration are given in Table 30, $U_{(L \text{ to } M)}$ being the nominal
1204 value between L+ or L- to mid-point M.

1205 *Compliance with the above requirements is checked by the tests of 9.24.*

1206 **8.18 Resistance to rusting**

1207 Ferrous parts shall be adequately protected against rusting.

1208 *Compliance is checked by the test of 9.23.*

1209 **8.19 Behaviour in case of making inrush current**

1210 *Under consideration*

1211 **8.20 Requirements for electronic components**

1212 *Under consideration*

1213 **8.21 Standing current in the FE under normal conditions**

1214 This subclause applies to DC-RCCBs classified according to 4.1.3.

1215 The standing current from the FE through the protective conductor shall not exceed 1 mA under
1216 normal supply conditions.

1217 *Compliance is checked by the test of 9.27.*

1218 **8.22 Standing current in the FE in case of DC-RCCB supplied from just one line** 1219 **and FE**

1220 This subclause applies to DC-RCCBs classified according to 4.1.3.

1221 When the DC-RCCB is supplied from just one line and FE, the standing current from the FE
1222 through the protective conductor shall not exceed 2 mA.

1223 *Compliance is checked by the test of 9.27.*

1224 **9 Tests**

1225 **9.1 General**

1226 The characteristics of DC-RCCBs are checked by means of type tests.

1227 For certification purposes, type tests are carried out in test sequences.

1228 NOTE: The term "certification" denotes:

- 1229 - either manufacturer's declaration of conformity; or
- 1230 - third-party certification, for example by an independent certification body.

1231 The test sequences and the number of samples are provided in Annex A.

1232 Unless otherwise specified, each type test (or sequence of type tests) is carried out on DC-
1233 RCCBs in a clean and new condition, the influencing quantities having their normal reference
1234 values (see Table 1).

1235 Routine tests to be carried out by the manufacturer on each device are given in Annex D.

1236 Guidance for follow-up testing program for DC-RCCBs is provided in Annex J.

1237 For DC-RCCBs classified according to 4.10.2 (non-polarized), and for switching tests only, two
1238 samples shall be tested with one supply polarity and one sample with supply connected in the
1239 other polarity.

1240 For DC-RCCBs classified according to 4.11.2 (bi-directional), two samples shall be tested by
1241 connecting the supply to one side of the device and one sample shall be tested by connecting
1242 the supply to the other side of the device.

1243 Unless otherwise specified, DC test voltages and currents shall have a ripple of $\omega \leq 5\%$ or
1244 have the minimum instantaneous value no lower than the required test value -5% and shall
1245 have no maximum instantaneous value higher than $+10\%$ of the required test value.

1246 9.2 Test conditions

1247 The DC-RCCB is mounted individually according to the manufacturer's instructions and in free
1248 air, at an ambient air temperature equal to $20\text{ }^{\circ}\text{C}$, unless otherwise specified, and is protected
1249 against undue external heating or cooling.

1250 DC-RCCBs designed for installation in individual enclosures are tested in the smallest of such
1251 enclosures specified by the manufacturer.

1252 NOTE 1 An individual enclosure is an enclosure designed to accept one device only.

1253 Unless otherwise specified, the DC-RCCB is wired with the appropriate cable of cross-section
1254 S specified in Table 25 and is fixed on a dull black painted plywood board not less than 20 mm
1255 thickness, the method of fixing being in compliance with the requirements relating to the
1256 indications of the manufacturer concerning mounting.

1257 NOTE 2 For AWG copper conductors, see Annex I.

1258 Where tolerances are not specified, type tests are carried out at values not less severe than
1259 those specified in this document.

1260 During the tests, no maintenance or dismantling of the samples is allowed.

1261 For the tests of 9.8, 9.9, 9.10, 9.20.2 and 9.21, the DC-RCCB is connected as follows:

- 1262 • the connections are made by means of single-core, PVC-insulated copper cables;
- 1263 • the connections are in free air and spaced not less than the distance existing between the
1264 terminals;
- 1265 • the minimum length of each temporary connection from terminal to terminal is
 - 1266 - 1 m for cross-sections up to and including 10 mm^2 ;
 - 1267 - 2 m for cross-sections larger than 10 mm^2 .

1268 The tightening torques to be applied to the terminal screws are two-thirds of those specified in
1269 Table 26.

1270 For DC-RCCBs with dependent manual operation, an operating speed of $0,1\text{ m/s} \pm 25\%$ shall
1271 be used during actuation for the tests of 9.10 and 9.11. The speed is measured at the extremity
1272 when and where the operating means of the test apparatus touches the actuating means of the
1273 DC-RCCB under test. For rotary knobs, the angular velocity shall correspond substantially to
1274 the above conditions, referred to the speed of the operating means (at its extremities) of the
1275 DC-RCCB under test.

1276 NOTE 3 In Japan, on request of the manufacturer, a different operating speed can be used for tests in 9.10 and
1277 9.11.

1278

9.3 Test of indelibility of marking

The test is carried out by rubbing the marking by hand for 15 s with a piece of cotton soaked with water and again for 15 s with a piece of cotton soaked with aliphatic solvent hexane with a content of aromatics of maximum 0,1 % volume, initial boiling point approximately 65 °C, dry point approximately 69 °C and specific gravity of 0,68 g/cm³.

Aliphatic solvent hexane having both the main composition required by this document and CAS No. 110-54-3 is acceptable.

Marking made by impressing, moulding, engraving or laser printing is not subjected to this test.

After this test, the marking shall be easily legible. The marking shall also remain easily legible after all the tests of this document.

It shall not be easily possible to remove labels and they shall show no curling.

9.4 Test of reliability of screws, current-carrying parts and connections

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when connecting the DC-RCCB, by the following test.

The screws or nuts are tightened and loosened:

- 10 times for screws in engagement with a thread of insulating material;

- 5 times in all other cases.

Screws or nuts in engagement with a thread of insulating material are completely removed and re-inserted each time.

The test is carried out by means of a suitable test screwdriver or spanner applying a torque as shown in Table 26.

The screws and nuts shall be tightened in one smooth and continuous motion.

The test is carried out with rigid conductors only, having the largest connectable cross-section specified in Table 24, solid or stranded, whichever is the more unfavourable. The conductor is moved each time the screw or nut is loosened.

Column I applies to screws without head if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

Column II applies to other screws which are tightened by means of a screwdriver.

Column III applies to screws and nuts which are tightened by means other than a screwdriver.

Where a screw has a hexagonal head with a slot for tightening with a screwdriver and the values in column II and column III are different, the test is carried out twice, first applying to the hexagonal head the torque specified in column III and then, on another sample, applying the torque specified in column II by means of a screwdriver. If the values in column II and column III are the same, only the test with the screwdriver is carried out.

During the test, the screwed connections shall not work loose and there shall be no damage, such as breakage of screws or deterioration to the head slots, threads, washers or stirrups, that will impair the further use of the DC-RCCB.

Moreover, enclosures and covers shall not be damaged.

9.5 Test of reliability of screw-type terminals for external copper conductors

9.5.1

Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, for which a rigid copper conductor having the largest cross-section specified in Table 24 is placed in the terminal (for nominal cross-sections exceeding 6 mm², a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of 9.5.2, 9.5.3 and 9.5.4.

The tests of 9.5.2, 9.5.3 and 9.5.4 are carried out using a suitable test screwdriver or spanner, and applying the torque specified in Table 26.

The terminals are fitted with copper conductors of the same type (solid, stranded or flexible) of the smallest and largest cross-sections specified in Table 24.

9.5.2

The terminal shall be suitable for all types of conductors: rigid (solid or stranded) and flexible, unless otherwise specified by the manufacturer.

Terminals shall be tested with the minimum and maximum cross-section of each type of conductors on new terminals as follows:

- tests for solid conductors shall use conductors having cross-sections from 1 mm² up to 6 mm², as applicable;
- tests for stranded conductors shall use conductors having cross-sections from 1,5 mm² up to 50 mm², as applicable;
- tests for flexible conductors shall use conductors having cross-sections from 1 mm² up to 35 mm², as applicable.

NOTE Information on AWG is given in Annex I.

The conductor is inserted into a new terminal for the minimum distance specified or, where no distance is specified, until it just projects from the far side, and in the position most likely to assist the wire to escape.

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 26.

Each conductor is then subjected to a pull of the value, in newtons, shown in Table 27, according to the relevant cross-section of the tested conductor.

The pull is applied without jerks, for 1 min, in the direction of the axis of the conductor space.

When it is necessary, the tested values, for the different cross-sections with the relevant pulling force, shall be clearly indicated in the test report.

During the test, the conductor shall not move noticeably in the terminal.

9.5.3

The terminals are fitted with copper conductors of the smallest and largest cross-sections specified in Table 24, solid or stranded, whichever is the more unfavourable, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 26.

The terminal screws are then loosened and the part of the conductor which may have been affected by the terminal is inspected.

1359 The conductors shall show no undue damage or severed wires.

1360 NOTE Conductors are considered to be unduly damaged if they show deep or sharp indentations.

1361 During the test, terminals shall not work loose and there shall be no damage, such as breakage
1362 of screws or damage to the head slots, threads, washers or stirrups, that will impair the further
1363 use of the terminal.

1364 **9.5.4**

1365 The terminals are fitted with the largest cross-section area specified in Table 24 for stranded
1366 and/or flexible copper conductor.

1367 Before insertion in the terminal, the strands of the conductor are suitably reshaped.

1368 The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal
1369 or just projects from the far side of the terminal and in the position most likely to permit a strand
1370 (or strands) to escape. The clamping screw or nut is then tightened with a torque equal to
1371 two-thirds of that shown in the appropriate column of Table 26.

1372 After the test, no strand of the conductor shall have escaped outside the retaining device.

1373 **9.6 Verification of protection against electric shock**

1374 This requirement is applicable to those parts of DC-RCCBs which are exposed to the operator
1375 when mounted as for normal use.

1376 The test is made with the standard test finger shown in Figure 1 on the DC-RCCB mounted as
1377 for normal use (see note of 8.2) and fitted with conductors of the smallest and largest
1378 cross-sections which may be connected to the DC-RCCB.

1379 The standard test finger shall be so designed that each of the jointed sections can be turned
1380 through an angle of 90° with respect to the axis of the finger, in the same direction only.

1381 The standard test finger is applied in every possible bending position of a real finger, an
1382 electrical contact indicator being used to show contact with live parts.

1383 It is recommended that a lamp be used for the indication of contact and that the voltage be not
1384 less than 40 V. The standard test finger shall not touch live parts.

1385 DC-RCCBs with enclosures or covers of thermoplastic material are subjected to the following
1386 additional test, which is carried out at an ambient air temperature of $(35 \pm 2) ^\circ\text{C}$, the DC-RCCB
1387 being at this temperature.

1388 DC-RCCBs are subjected for 1 min to a force of 75 N, applied through the tip of a straight
1389 unjointed test finger (probe 11 according to IEC 61032). This finger is applied to all places
1390 where yielding of insulating material could impair the safety of the DC-RCCB but is not applied
1391 to knock-outs.

1392 During this test, enclosures or covers shall not deform to such an extent that live parts can be
1393 touched with the unjointed test finger.

1394 Unenclosed DC-RCCBs having parts not intended to be covered by an enclosure are submitted
1395 to the test with a metal front panel and mounted as for normal use.

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the DC-RCCB for test

Parts of the DC-RCCB which can be removed without the aid of a tool, are removed and subjected to the humidity treatment with the main part; spring lids are kept open during this treatment.

Inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

9.7.1.2 Test conditions

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air in which the sample is placed is maintained within ± 1 °C of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between T °C and T °C + 4 °C.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large surface in contact with the air.

In order to achieve the specified conditions within the cabinet, it is recommended to ensure a constant circulation of the air within and to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the DC-RCCB after the test

After this treatment, the sample shall show no damage within the meaning of this standard and shall withstand the tests of 9.7.2, 9.7.3, 9.7.4, 9.7.6 and 9.7.7.2 (if applicable).

9.7.2 Insulation resistance of the main circuit

The DC-RCCB having been treated as specified in 9.7.1 is then removed from the cabinet.

After an interval of between 30 min and 60 min following this treatment, the insulation resistance is measured 5 s after the application of a d.c. voltage of approximately 500 V, in the following order:

- a) with the DC-RCCB in the open position, between each pair of the terminals which are electrically connected together when the DC-RCCB is in the closed position, in turn on each pole;
- b) with the DC-RCCB in the closed position, in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test. For DC-RCCBs classified according to 4.1.4 and 4.1.5 not remaining in the closed position, each pole is bridged by an external connection;
- c) with the DC-RCCB in the closed position, between all poles connected together and the frame including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil. For DC-RCCBs classified according to 4.1.4 and 4.1.5 not remaining in the closed position, each pole is bridged by an external connection;

1437 d) for DC-RCCBs with a metal enclosure having an internal lining of insulating material,
1438 between the frame and a metal foil in contact with the inner surface of the lining of insulating
1439 material, including bushings and similar devices.

1440 The measurement of c) is carried out after having connected all auxiliary circuits to the frame.

1441 The term "frame" includes:

- 1442 – all accessible metal parts and a metal foil in contact with the surfaces of insulating material
1443 which are accessible after installation as for normal use;
- 1444 – the surface on which the base of the DC-RCCB is mounted, covered, if necessary, with
1445 metal foil;
- 1446 – screws and other devices for fixing the base to its support;
- 1447 – screws for fixing covers which have to be removed when mounting the DC-RCCB;
- 1448 – metal parts of operating means referred to in 8.2.

1449 If the DC-RCCB is provided with a terminal intended for the connection of protective conductors,
1450 this is connected to the frame.

1451 For the measurements according to list items c) and d), the metal foil is applied in such a way
1452 that the sealing compound, if any, is effectively tested.

1453 The insulation resistance shall not be less than:

- 1454 – 2 MΩ for the measurements according to a) and b);
- 1455 – 5 MΩ for the other measurements.

1456 **9.7.3 Dielectric strength of the main circuit**

1457 After the DC-RCCB has passed the tests of 9.7.2, the test voltage specified is applied for 1 min
1458 between the parts indicated in 9.7.2 with electronic components, if any, being disconnected for
1459 the test.

1460 For this test, DC or AC voltage may be used

1461 The DC test voltage shall be substantially free of ripple. This requirement is fulfilled if the ratio
1462 between the peak values of the voltage and the average value is $1,0 \% \pm 3 \%$.

1463 The AC test voltage shall have a practically sinusoidal waveform, and a frequency between
1464 45 Hz and 65 Hz.

1465 The source of the test voltage shall be capable of supplying a short-circuit current of at least
1466 0,2 A.

1467 No overcurrent tripping device of the transformer shall operate when the current in the output
1468 circuit is lower than 100 mA.

1469 The values of the test voltage shall be as follows:

- 1470 – 2 000 V AC or 2 830 V DC for a) to c) of 9.7.2;
- 1471 – 2 500 V AC or 3 535 V DC for d) of 9.7.2.

1472 Initially, not more than half the prescribed voltage is applied, then it is raised to the full value
1473 within 5 s.

1474 No flashover or breakdown shall occur during the test.

1475 Glow discharges without drop in voltage are neglected.