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Title: BS EN IEC 60204-1 ED7 Safety of machinery - Electrical equipment of machines

Part 1: General requirements

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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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UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.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.	



44/1049/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 60204-1 ED7	
DATE OF CIRCULATION: 2024-08-09	CLOSING DATE FOR COMMENTS: 2024-10-04
SUPERSEDES DOCUMENTS: 44/988/RR	

IEC TC 44 : SAFETY OF MACHINERY - ELECTROTECHNICAL ASPECTS	
SECRETARIAT: United Kingdom	SECRETARY: Mrs Nyomee Hla-Shwe Tun
OF INTEREST TO THE FOLLOWING COMMITTEES:	HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED: Safety	

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TITLE:
Safety of machinery - Electrical equipment of machines - Part 1: General requirements

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CONTENTS

1		
2		
3	FOREWORD.....	10
4	INTRODUCTION.....	13
5	General	13
6	Requirements covered by other relevant parts of the IEC 60204 series	14
7	1 Scope.....	15
8	2 Normative references	16
9	3 Terms, definitions and abbreviated terms	17
10	3.1 Terms and definitions.....	17
11	3.2 Abbreviated terms.....	26
12	4 General requirements	27
13	4.1 General.....	27
14	4.2 Selection of equipment	28
15	4.2.1 General	28
16	4.2.2 Switchgear	28
17	4.2.3 Power Drive Systems.....	28
18	4.3 Electrical supply.....	28
19	4.3.1 General	28
20	4.3.2 AC supplies	29
21	4.3.3 DC supplies	29
22	4.3.4 Special supply systems	29
23	4.4 Physical environment and operating conditions	29
24	4.4.1 General	29
25	4.4.2 Ambient air temperature	30
26	4.4.3 Humidity	30
27	4.4.4 Altitude	30
28	4.4.5 Contaminants	30
29	4.4.6 Ionizing and non-ionizing radiation	30
30	4.4.7 Vibration, shock, and bump	30
31	4.5 Transportation and storage	31
32	4.6 Provisions for handling	31
33	4.7 Electromagnetic compatibility (EMC).....	31
34	5 Incoming supply conductor terminations and devices for disconnecting and	
35	switching off	31
36	5.1 Incoming supply conductor terminations.....	31
37	5.2 Terminal for connection of the external protective conductor	32
38	5.3 Supply disconnecting (isolating) device	33
39	5.3.1 General	33
40	5.3.2 Type	33
41	5.3.3 Requirements	34
42	5.3.4 Operating means of the supply disconnecting device	34
43	5.3.5 Excepted circuits	36
44	5.4 Devices for removal of power for prevention of unexpected start-up.....	36
45	5.5 Devices for isolating electrical equipment	37
46	5.6 Protection against unauthorized, inadvertent and/or mistaken connection	37

47	6	Protection against electric shock	38
48	6.1	General.....	38
49	6.2	Basic protection	38
50	6.2.1	General	38
51	6.2.2	Protection by enclosures	38
52	6.2.3	Protection by insulation of live parts	39
53	6.2.4	Protection against residual voltages	39
54	6.2.5	Protection by barriers	40
55	6.2.6	Protection by placing out of reach or protection by obstacles	40
56	6.3	Fault protection.....	40
57	6.3.1	General	40
58	6.3.2	Prevention of the occurrence of a touch voltage	40
59	6.3.3	Protection by automatic disconnection of supply	41
60	6.4	Protection by the use of PELV	41
61	6.4.1	General requirements	41
62	6.4.2	Sources for PELV	42
63	7	Protection of equipment.....	42
64	7.1	General.....	42
65	7.2	Overcurrent protection	42
66	7.2.1	General	42
67	7.2.2	Supply conductors	43
68	7.2.3	Power circuits	43
69	7.2.4	Control circuits	43
70	7.2.5	Socket outlets and their associated conductors	43
71	7.2.6	Lighting circuits	44
72	7.2.7	Transformers	44
73	7.2.8	Location of overcurrent protective devices	44
74	7.2.9	Overcurrent protective devices	44
75	7.2.10	Rating and setting of overcurrent protective devices	44
76	7.3	Protection of motors against overheating	45
77	7.3.1	General	45
78	7.3.2	Overload protection	45
79	7.3.3	Over-temperature protection	45
80	7.4	Protection against operating under abnormal temperature	46
81	7.5	Protection against the effects of supply interruption or voltage reduction and subsequent restoration	46
82	7.6	Motor overspeed protection.....	46
83	7.7	Additional earth fault/residual current protection	46
84	7.8	Phase sequence protection	46
85	7.9	Protection against overvoltages due to lightning and to switching surges	47
86	7.10	Short-circuit current rating	47
87	8	Equipotential bonding	47
88	8.1	General.....	47
89	8.2	Protective bonding circuit.....	49
90	8.2.1	General	49
91	8.2.2	Protective conductors	50
92	8.2.3	Continuity of the protective bonding circuit	51
93	8.2.4	Protective conductor connecting points.....	51
94	8.2.5	Mobile machines.....	52

96	8.2.6	Additional requirements for electrical equipment having earth leakage currents higher than 10 mA.....	52
97			
98	8.3	Measures to restrict the effects of high leakage current	53
99	8.4	Functional bonding	53
100	9	Control circuits and control functions	54
101	9.1	Control circuits.....	54
102	9.1.1	Control circuit supply	54
103	9.1.2	Control circuit voltages	54
104	9.1.3	Protection	54
105	9.2	Control functions.....	54
106	9.2.1	General	54
107	9.2.2	Categories of stop functions	54
108	9.2.3	Operation	55
109	9.2.4	Cableless control system (CCS)	58
110	9.3	Protective interlocks	60
111	9.3.1	Reclosing or resetting of an interlocking safeguard	60
112	9.3.2	Exceeding operating limits	60
113	9.3.3	Operation of auxiliary functions	60
114	9.3.4	Interlocks between different operations and for contrary motions	60
115	9.3.5	Reverse current braking	60
116	9.3.6	Suspension of safety functions and/or protective measures	61
117	9.4	Control functions in the event of failure	61
118	9.4.1	General requirements	61
119	9.4.2	Measures to minimize risk in the event of failure	61
120	9.4.3	Protection against malfunction of control circuits	62
121	10	Operator interface and machine-mounted control devices	70
122	10.1	General.....	70
123	10.1.1	General requirements	70
124	10.1.2	Location and mounting	70
125	10.1.3	Protection	70
126	10.1.4	Position sensors	71
127	10.1.5	Portable and pendant control stations	71
128	10.1.6	Electrosensitive protective devices	71
129	10.2	Actuators	71
130	10.2.1	Colours.....	71
131	10.2.2	Markings.....	72
132	10.3	Indicator lights and displays	72
133	10.3.1	General	72
134	10.3.2	Colours.....	73
135	10.3.3	Flashing lights and displays	73
136	10.4	Illuminated push-buttons	73
137	10.5	Rotary control devices	74
138	10.6	Start devices	74
139	10.7	Emergency stop devices	74
140	10.7.1	Location of emergency stop devices	74
141	10.7.2	Types of devices for emergency stop	74
142	10.7.3	Operation of the supply disconnecting device to effect emergency stop	74
143	10.8	Emergency switching off devices	75
144	10.8.1	Location of emergency switching off devices	75

145	10.8.2	Types of devices for emergency switching off	75
146	10.8.3	Local operation of the supply disconnecting device to effect emergency	
147		switching off	75
148	10.9	Enabling control device	75
149	11	Controlgear: location, mounting, and enclosures	75
150	11.1	General requirements	75
151	11.2	Location and mounting	76
152	11.2.1	Accessibility and maintenance	76
153	11.2.2	Physical separation or grouping	77
154	11.2.3	Heating effects	77
155	11.3	Degrees of protection.....	78
156	11.4	Enclosures, doors and openings	79
157	11.5	Access to electrical equipment.....	79
158	12	Conductors and cables	80
159	12.1	General requirements	80
160	12.2	Conductors	80
161	12.3	Insulation	81
162	12.4	Current-carrying capacity in normal service	81
163	12.5	Voltage drop	82
164	12.6	Flexible cables.....	83
165	12.6.1	General	83
166	12.6.2	Mechanical rating	83
167	12.6.3	Current-carrying capacity of cables wound on drums	83
168	12.7	Conductor wires, conductor bars and slip-ring assemblies	84
169	12.7.1	Basic protection.....	84
170	12.7.2	Protective conductors	84
171	12.7.3	Protective conductor current collectors	85
172	12.7.4	Removable current collectors with a disconnecter function	85
173	12.7.5	Clearances in air	85
174	12.7.6	Creepage distances.....	85
175	12.7.7	Conductor system sectioning	85
176	12.7.8	Construction and installation of conductor wire, conductor bar systems	
177		and slip-ring assemblies	85
178	13	Wiring practices.....	86
179	13.1	Connections and routing	86
180	13.1.1	General requirements	86
181	13.1.2	Conductor and cable runs.....	87
182	13.1.3	Conductors and cables of different circuits	87
183	13.1.4	AC circuits – Electromagnetic effects (prevention of eddy currents)	87
184	13.1.5	Connection between pick-up and pick-up converter of an inductive	
185		power supply system	87
186	13.2	Identification of conductors	88
187	13.2.1	General requirements	88
188	13.2.2	Identification of the protective conductor / protective bonding conductor	88
189	13.2.3	Identification of the neutral conductor	89
190	13.2.4	Identification by colour.....	90
191	13.3	Wiring inside enclosures	90
192	13.4	Wiring outside enclosures	91
193	13.4.1	General requirements	91

194	13.4.2	External ducts	91
195	13.4.3	Connection to moving elements of the machine	91
196	13.4.4	Interconnection of devices on the machine	92
197	13.4.5	Plug/socket combinations	92
198	13.4.6	Dismantling for shipment	93
199	13.4.7	Additional conductors	93
200	13.5	Ducts, connection boxes and other boxes	93
201	13.5.1	General requirements	93
202	13.5.2	Rigid metal conduit and fittings	94
203	13.5.3	Flexible metal conduit and fittings	94
204	13.5.4	Flexible non-metallic conduit and fittings	94
205	13.5.5	Cable trunking systems	94
206	13.5.6	Machine compartments and cable trunking systems.....	95
207	13.5.7	Connection boxes and other boxes	95
208	13.5.8	Motor connection boxes.....	95
209	14	Electric motors and associated equipment	95
210	14.1	General requirements	95
211	14.2	Motor enclosures	95
212	14.3	Motor dimensions.....	96
213	14.4	Motor mounting and compartments	96
214	14.5	Criteria for motor selection.....	96
215	14.6	Protective devices for mechanical brakes	96
216	15	Socket-outlets and lighting	97
217	15.1	Socket-outlets for accessories	97
218	15.2	Local lighting of the machine and of the equipment	97
219	15.2.1	General	97
220	15.2.2	Supply	97
221	15.2.3	Protection	98
222	15.2.4	Fittings	98
223	16	Marking, warning signs and reference designations	98
224	16.1	General.....	98
225	16.2	Warning signs	98
226	16.2.1	Electric shock hazard	98
227	16.2.2	Hot surfaces hazard	99
228	16.3	Functional identification	100
229	16.4	Marking of enclosures of electrical equipment	100
230	16.5	Reference designations	100
231	17	Technical documentation	101
232	17.1	General.....	101
233	17.2	Information related to the electrical equipment	101
234	18	Verification	101
235	18.1	General.....	101
236	18.2	Verification of conditions for protection by automatic disconnection of supply	102
237	18.2.1	General	102
238	18.2.2	Test 1 – Verification of the continuity of the protective bonding circuit	102
239	18.2.3	Test 2 – Fault loop impedance verification and suitability of the	
240		associated overcurrent protective device	103
241	18.2.4	Application of the test methods for TN-systems	103

242	18.3	Insulation resistance tests.....	108
243	18.4	Voltage tests.....	108
244	18.5	Protection against residual voltages.....	108
245	18.6	Functional tests	108
246	18.7	Retesting	108
247	Annex A (normative)	Fault protection by automatic disconnection of supply	109
248	A.1	Fault protection for machines supplied from TN-systems	109
249	A.1.1	General	109
250	A.1.2	Conditions for protection by automatic disconnection of the supply by	
251		overcurrent protective devices	110
252	A.1.3	Condition for protection by reducing the touch voltage below 50 V.....	110
253	A.1.4	Verification of conditions for protection by automatic disconnection of	
254		the supply.....	111
255	A.2	Fault protection for machines supplied from TT-systems.....	112
256	A.2.1	Connection to earth	112
257	A.2.2	Fault protection for TT systems	113
258	A.2.3	Verification of protection by automatic disconnection of supply using a	
259		residual current protective device	115
260	A.2.4	Measurement of the fault loop impedance (Z_S)	115
261	Annex B (informative)	Enquiry form for the electrical equipment of machines.....	117
262	Annex C (informative)	Examples of machines covered by this part of IEC 60204	122
263	Annex D (informative)	Current-carrying capacity and overcurrent protection of	
264		conductors and cables in the electrical equipment of machines	125
265	D.1	General.....	125
266	D.2	General operating conditions	125
267	D.2.1	Ambient air temperature	125
268	D.2.2	Methods of installation.....	125
269	D.2.3	Grouping	128
270	D.2.4	Classification of conductors	130
271	D.3	Co-ordination between conductors and protective devices providing overload	
272		protection.....	130
273	D.4	Overcurrent protection of conductors	131
274	D.5	Effect of harmonic currents on balanced three-phase systems	132
275	Annex E (informative)	Explanation of emergency operation functions.....	133
276	Annex F (informative)	Guide for the use of this part of IEC 60204	134
277	Annex G (informative)	Comparison of typical conductor cross-sectional areas	138
278	Annex H (informative)	Measures to reduce the effects of electromagnetic influences	140
279	H.1	Definitions	140
280	H.1.1	apparatus	140
281	H.1.2	fixed installation	140
282	H.2	General.....	140
283	H.3	Mitigation of electromagnetic interference (EMI)	141
284	H.3.1	General	141
285	H.3.2	Measures to reduce EMI	141
286	H.4	Separation and segregation of cables	142
287	H.5	Power supply of a machine by parallel sources	145
288	H.6	Supply impedance where a Power Drive System (PDS) is used	145
289	Annex I (informative)	Documentation / Information	146
290	Bibliography.....		148

291		
292	Figure 1 – Block diagram of a typical machine	14
293	Figure 2 – Disconnecter isolator	35
294	Figure 3 – Disconnecting circuit breaker	35
295	Figure 4 – Example of equipotential bonding for electrical equipment of a machine	49
296	Figure 5 – Symbol IEC 60417–5019: Protective earth	52
297	Figure 6 – Symbol IEC 60417–5020: Frame or chassis	53
298	Figure 7 – Method a) Earthed control circuit fed by a transformer	63
299	Figure 8 – Method b1) Non-earthed control circuit fed by transformer	64
300	Figure 9 – Method b2) Non-earthed control circuit fed by transformer	65
301	Figure 10 – Method b3) Non-earthed control circuit fed by transformer	66
302	Figure 11 – Method c) Control circuits fed by transformer with an earthed centre-tap	
303	winding	67
304	Figure 12 – Method d1a) Control circuit without transformer connected between a	
305	phase and the neutral of an earthed supply system	68
306	Figure 13 – Method d1b) Control circuit without transformer connected between two	
307	phases of an earthed supply system	68
308	Figure 14 – Method d2a) Control circuit without transformer connected between phase	
309	and neutral of a non-earthed supply system	69
310	Figure 15 – Method d2b) control circuit without transformer connected between two	
311	phases of a non-earthed supply system	69
312	Figure 16 – Symbol IEC 60417–5019	89
313	Figure 17 – Symbol IEC 60417–5021	89
314	Figure 18 – Symbol ISO 7010-W012	99
315	Figure 19 – Symbol ISO 7010-W017	100
316	Figure A.1 – Typical arrangement for fault loop impedance (Z_s) measurement in TN	
317	systems	112
318	Figure A.2 – Typical arrangement for fault loop impedance (Z_s) measurement for	
319	power drive system circuits in TN systems	112
320	Figure A.3 – Typical arrangement for fault loop impedance (Z_s) measurement in TT	
321	systems	116
322	Figure A.4 – Typical arrangement for fault loop impedance (Z_s) measurement for	
323	power drive system circuits in TT systems	116
324	Figure D.1 – Conductors/single core cables in conduit and cable trunking systems	126
325	Figure D.2 – Cables in conduit and cable trunking systems	127
326	Figure D.3 – Cables on walls	127
327	Figure D.4 – Cables on open cable trays	128
328	Figure D.5 – Methods of conductor and cable installation independent of number of	
329	conductors/cables	128
330	Figure D.6 – Parameters of conductors and protective devices	130
331	Figure H.1 – By-pass conductor for screen reinforcement	141
332	Figure H.2 – Examples of vertical separation and segregation	143
333	Figure H.3 – Examples of horizontal separation and segregation	144
334	Figure H.4 – Cable arrangements in metal cable trays	144
335	Figure H.5 – Connections between metal cable trays or cable trunking systems	145
336	Figure H.6 – Interruption of metal cable trays at fire barriers	145

337		
338	Table 1 – Minimum cross-sectional area of copper protective conductors	33
339	Table 2 – Symbols for actuators (Power)	72
340	Table 3 – Symbols for actuators (Machine operation)	72
341	Table 4 – Colours for indicator lights and their meanings with respect to the condition	
342	of the machine	73
343	Table 5 – Minimum cross-sectional areas of copper conductors	80
344	Table 6 – Examples of current-carrying capacity (I _z) of PVC insulated copper	
345	conductors or cables under steady-state conditions in an ambient air temperature of	
346	+40 °C for different methods of installation	82
347	Table 7 – Derating factors for cables wound on drums	84
348	Table 8 – Minimum permitted bending radii for the forced guiding of flexible cables	92
349	Table 9 – Application of the test methods for TN-systems	104
350	Table 10 – Examples of maximum cable lengths from protective devices to their loads	
351	for TN-systems	107
352	Table A.1 – Maximum disconnecting times for TN systems	109
353	Table A.2 – Maximum disconnecting time for TT-systems	114
354	Table D.1 – Correction factors	125
355	Table D.2 – Derating factors for I _z for grouping	129
356	Table D.3 – Derating factors for I _z for multicore cables up to 10 mm ²	129
357	Table D.4 – Classification of conductors	130
358	Table D.5 – Maximum allowable conductor temperatures under normal and short-circuit	
359	conditions	132
360	Table F.1 – Application options	135
361	Table G.1 – Comparison of conductor sizes	138
362	Table H.1 – Minimum separation distances using metallic containment as illustrated in	
363	Figure H.2	142
364	Table I.1 – Documentation / Information that can be applicable	147
365		
366		

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF MACHINERY - ELECTRICAL EQUIPMENT OF MACHINES -
PART 1: GENERAL REQUIREMENTS –**

FOREWORD

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IEC 60204–1 edition 6.1 contains the sixth edition (2016-10) [documents 44/765/FDIS and 44/771/RVD] and its amendment 1 (2021-09) [documents 44/884/CDV and 44/913/RVC].

418 **This Final version does not show where the technical content is modified by amendment**
419 **1. A separate Redline version with all changes highlighted is available in this publication.**

420 International Standard IEC 60204–1 has been prepared by IEC technical committee 44: Safety
421 of machinery – Electrotechnical aspects.

422 This sixth edition constitutes a technical revision.

423 This edition includes the following significant technical changes with respect to the previous
424 edition:

425 added requirements to address applications involving power drive systems ([PDS](#));
426 revised electromagnetic compatibility ([EMC](#)) requirements;
427 clarified overcurrent protection requirements;
428 requirements for determination of the short circuit current rating of the electrical equipment;
429 revised protective bonding requirements and terminology;
430 reorganization and revision to [Clause 9](#), including requirements pertaining to safe torque off
431 of [PDS](#), emergency stop, and control circuit protection;
432 revised symbols for actuators of control devices;
433 revised technical documentation requirements;
434 general updating to current special national conditions, normative standards, and
435 bibliographical references.

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

437 A list of all parts in the IEC 60204 series, published under the general title *Safety of machinery*
438 – *Electrical equipment of machines*, can be found on the IEC website.

439 The following differing practices of a less permanent nature exist in the countries indicated
440 below.

4.3.1:	The voltage characteristics of electricity supplied by public distribution systems in Europe are given in EN 50160:2010.
5.1:	Exception is not allowed (USA).
5.1:	TN-C systems are not permitted in low-voltage installations in buildings (Norway).
5.2:	Terminals for the connection of the protective earthing conductors may be identified by the colour green, the letters "G" or "GR" or "GRD" or "GND", or the word "ground" or "grounding", or with the graphical symbol IEC 60417-5019:2006-08 or any combination (USA).
6.3.3 b), 13.4.5 b), 18.2.1:	TT power systems are not allowed (USA).
6.3.3, 18.2, Annex A:	TN systems are not used. TT systems are the national standard (Japan).
6.3.3 b):	The use of residual current protective devices with a rated residual operating current which is coordinated with the earth electrode resistance is mandatory in TT systems as a means for fault protection by automatic disconnection of supply (Italy).
7.2.3:	Disconnection of the neutral conductor is mandatory in a TN-S system (France).
7.2.3:	Disconnection of the neutral conductor is mandatory in TN-systems (Norway).
7.2.3:	Third paragraph: distribution of a neutral conductor with an IT system is not allowed (USA and Norway).
7.10:	For evaluation of short circuit ratings the requirements of UL 508A Supplement SB, may be used (USA).
8.2.2:	See IEC 60364-5-54:2011, Annex E List of notes concerning certain countries.
9.1.2:	Maximum nominal AC control circuit voltage is 120 V (USA).
12.2:	Only stranded conductors are allowed on machines, except for 0,2 mm ² solid conductors within enclosures (USA).
12.2:	The smallest power circuit conductor allowed on machines is 0,82 mm ² (AWG 18) in multiconductor cables or in enclosures (USA).
Table 5:	Cross-sectional area is specified in NFPA 79 using American Wire Gauge (AWG) (USA). See Annex G.
13.2.2:	For the protective conductor, the colour identification GREEN (with or without YELLOW stripes) is used as equivalent to the bicolour combination GREEN-AND-YELLOW (USA and Canada).
13.2.3:	The colour identification WHITE or GREY is used for earthed neutral conductors instead of the colour identification BLUE (USA and Canada).
15.2.2:	First paragraph: Maximum value between conductors 150 V (USA).
15.2.2:	Second paragraph, 5 th bullet: The full load current rating of lighting circuits does not exceed 15 A (USA).
16.4:	Nameplate marking requirements (USA).
A.2.2.2:	The permissible maximum value of R_A is regulated (e.g. when $U_0 \geq 300V$, R_A shall be less than 10 Ω , when $U_0 < 300 V$, R_A shall be less than 100 Ω , U_0 is the nominal AC line to earth voltage in volts (V) (Japan).
A.2.2.2:	The maximum permissible value of R_A is 83 Ω (Netherlands).

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

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

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

451

452

INTRODUCTION

453

General

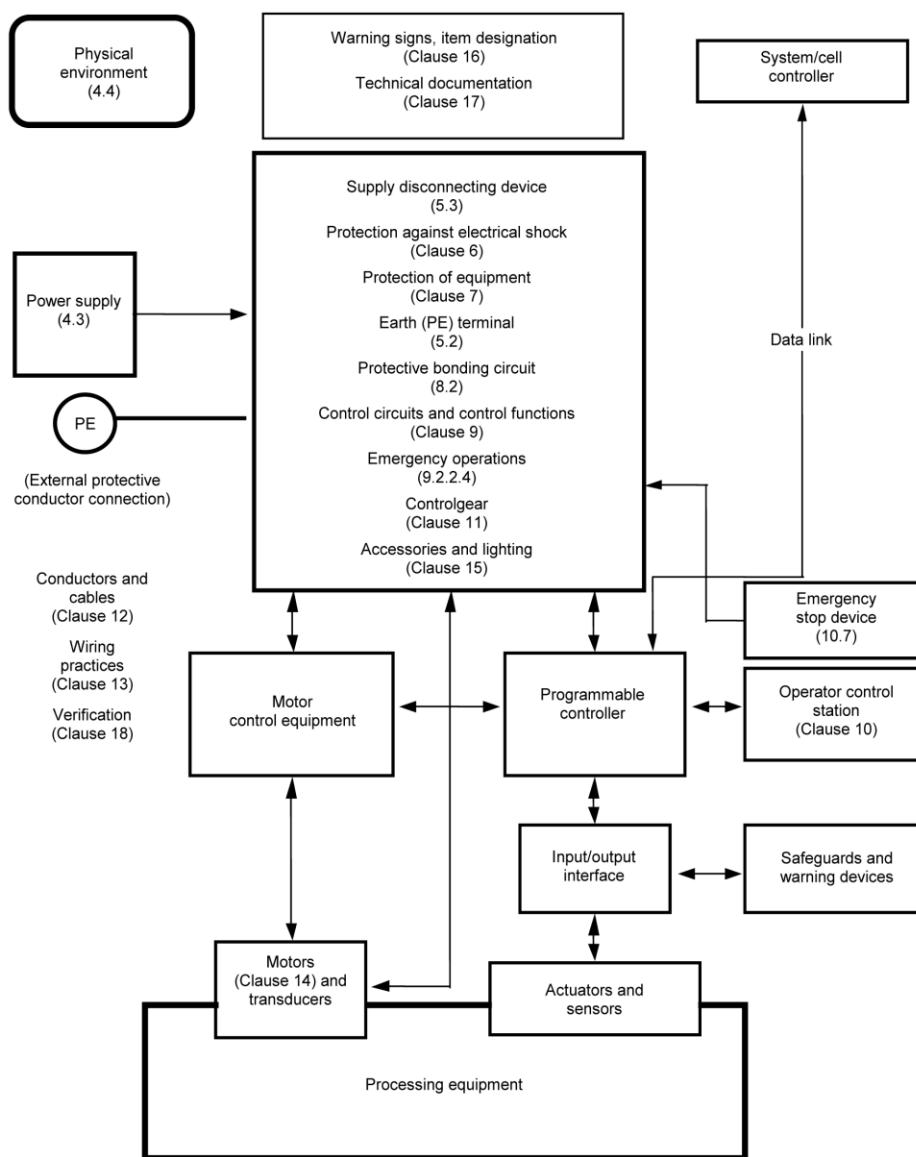
454 This part of IEC 60204 provides requirements and recommendations relating to the electrical
455 equipment of machines so as to promote:

- 456 safety of persons and property;
- 457 consistency of control response;
- 458 ease of operation and maintenance.

459 More guidance on the use of this part of IEC 60204 is given in [Annex F](#).

460 [Figure 1](#) has been provided as an aid to the understanding of the inter-relationship of the various
461 elements of a machine and its associated equipment. [Figure 1](#) is a block diagram of a typical
462 machine and associated equipment showing the various elements of the electrical equipment
463 addressed in this part of IEC 60204. Numbers in parentheses () refer to Clauses and
464 Subclauses in this part of IEC 60204. It is understood in [Figure 1](#) that all of the elements taken
465 together including the safeguards, tooling/fixtures, software, and the documentation, constitute
466 the machine, and that one or more machines working together with usually at least one level of
467 supervisory control constitute a manufacturing cell or system.

468



IEC

469

470

Figure 1 – Block diagram of a typical machine

471

Requirements covered by other relevant parts of the IEC 60204 series

472

equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV are covered by IEC 60204-11;

473

474

sewing machines, units, and systems are covered by IEC 60204-31;

475

hoisting machines are covered by IEC 60204-32;

476

semiconductor fabrication equipment are covered by IEC 60204-33.

477

NOTE Additional information regarding electrical equipment of machine tools can be found in IEC TS 60204-34

478

479

SAFETY OF MACHINERY - ELECTRICAL EQUIPMENT OF MACHINES - PART 1: GENERAL REQUIREMENTS –

1 Scope

This part of IEC 60204 applies to electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a co-ordinated manner.

In this part of IEC 60204, the term “electrical” includes electrical, electronic and programmable electronic matters (i.e. “electrical equipment” means electrical, electronic and programmable electronic equipment).

This part of IEC 60204 is an application standard and is not intended to limit or inhibit technological advancement.

The equipment covered by this part of IEC 60204 commences at the point of connection of the supply to the electrical equipment of the machine (see 5.1).

The requirements for the electrical supply installation are given in the IEC 60364 series.

This part of IEC 60204 is applicable to the electrical equipment or parts of the electrical equipment that operate with nominal supply voltages not exceeding 1 000 V for alternating current (AC) and not exceeding 1 500 V for direct current (DC), and with nominal supply frequencies not exceeding 200 Hz.

Information on electrical equipment or parts of the electrical equipment that operate with higher nominal supply voltages can be found in IEC 60204–11.

This part of IEC 60204 does not cover all the requirements (for example guarding, interlocking, or control) that are needed or required by other standards or regulations in order to protect persons from hazards other than electrical hazards. Each type of machine has unique requirements to be accommodated to provide adequate safety.

In the context of this part of IEC 60204, the term “person” refers to any individual and includes those persons who are assigned and instructed by the user or his agent(s) in the use and care of the machine in question.

This part of IEC 60204 specifically includes, but is not limited to, the electrical equipment of machines as defined in machine (3.1.42) .

Annex C lists examples of machines whose electrical equipment can be covered by this part of IEC 60204.

This part of IEC 60204 does not specify additional and special requirements that can apply to the electrical equipment of machines that, for example:

- are intended for use in open air (i.e. outside buildings or other protective structures);
- are intended for use in or for machinery containing conducting locations with restricted movement (see IEC 60364-7-706).
- use, process, or produce potentially explosive material (for example paint or sawdust);
- are intended for use in potentially explosive and/or flammable atmospheres;

521 have special risks when producing or using certain materials;
522 are intended for use in mines;
523 are exposed to seismic risk;
524 are intended for use in laboratories (see IEC 61010 Series);
525 use electrical energy directly as a working .

526 **2 Normative references**

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

531 IEC 60072 (all parts), *Dimensions and output series for rotating electrical machines*

532 IEC 60309–1, *Plugs, socket-outlets, and couplers for industrial purposes – Part 1: General*
533 *requirements*

534 IEC 60364–1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment*
535 *of general characteristics, definitions*

536 IEC 60364–4–41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety –*
537 *Protection against electric shock*

538 IEC 60364–4–43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety –*
539 *Protection against overcurrent*

540 IEC 60364–5–52:2009, *Low-voltage electrical installations – Part 5-52: Selection and erection*
541 *of electrical equipment – Wiring systems*

542 IEC 60364–5–53:2019, *Low-voltage electrical installations – Part 5-53: Selection and erection*
543 *of electrical equipment – Devices for protection for safety, isolation, switching, control and*
544 *monitoring*

545 IEC 60364–5–54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection*
546 *of electrical equipment – Earthing arrangements and protective conductors*

547 IEC 60364–6:2016, *Low-voltage electrical installations – Part 6: Verification*

548 IEC 60364-7-706:2005+AMD1:2019 CSV:2019, *Low-voltage electrical installations - Part 7-706:*
549 *Requirements for special installations or locations - Conducting locations with restricted*
550 *movement*

551 IEC 60417, *Graphical symbols for use on equipment. Available from: [http://www.graphical-](http://www.graphical-symbols.info/equipment)*
552 *symbols.info/equipment*

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

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

556 IEC 60947–2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

557 IEC 60947–3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors,*
558 *switch-disconnectors, and fuse-combination units*

- 559 IEC 60947–5–1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit*
560 *devices and switching elements – Electromechanical control circuit devices*
- 561 IEC 60947–5–5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and*
562 *switching elements – Electrical emergency stop device with mechanical latching function*
- 563 IEC 60947–6–2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function*
564 *equipment – Control and protective switching devices(or equipment) (CPS)*
- 565 IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*
- 566 IEC 61310 (all parts), *Safety of machinery – Indication, marking and actuation*
- 567 IEC 61439–1, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*
- 568 IEC 61558–1:2017, *Safety of transformers, reactors, power supply units and combinations*
569 *thereof – Part 1: General requirements and tests*
- 570 IEC 61558–2–6, *Safety of transformers, reactors, power supply units and similar products for*
571 *supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating*
572 *transformers and power supply units incorporating safety isolating transformers*
- 573 IEC 61984, *Connectors – Safety requirements and tests*
- 574 IEC 62023, *Structuring of technical information and documentation*
- 575 IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and*
576 *programmable electronic control systems*
- 577 IEC 62745:2017, *Safety of machinery - Requirements for cableless control systems of*
578 *machinery*
- 579 ISO 7010:2019, *Graphical symbols – Safety colours and safety signs – Registered safety signs*
- 580 ISO 13849–1, *Safety of machinery – Safety-related parts of control systems – Part 1: General*
581 *principles for design*
- 582 ISO 13849–2, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*
- 583 ISO 13850:2015, *Safety of machinery – Emergency stop function – Principles for design*
- 584 IEC 60364–4–41:2005/AMD1:2017,

585 **3 Terms, definitions and abbreviated terms**

586 **3.1 Terms and definitions**

587 For the purposes of this document, the following terms and definitions apply.

588 **3.1.1**

589 **actuator**

590 part of a device to which an external action is to be applied

591 Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

592 Note 2 to entry: There are some actuating means that do not require an external actuating force, but only an action,
593 e.g. touchscreens.

594 Note 3 to entry: See also [machine actuator \(3.1.41\)](#) .

595 **3.1.2**
596 **active(operator interface device)**
597 ready to perform its specific intended function(s)

598 **3.1.3**
599 **ambient temperature**
600 temperature of the air or other medium where the equipment is to be used

601 **3.1.4**
602 **barrier**
603 part providing protection against contact with live parts from any usual direction of access

604 **3.1.5**
605 **basic protection**
606 protection against electric shock under fault-free conditions

607 Note 1 to entry: Previously referred to as “protection against direct contact”

608 [SOURCE: IEC 60050–195:1998, 195-06-01, modified – The note has been added.]

609 **3.1.6**
610 **cable tray**
611 cable support consisting of a continuous base and raised edges and no covering

612 Note 1 to entry: A cable tray may be perforated or non-perforated.

613 [SOURCE: IEC 60050–826:2004, 826-15-08]

614 **3.1.7**
615 **cable trunking system**
616 system of closed enclosures comprising a base with a removable cover intended for the
617 complete surrounding of insulated conductors or cables

618 **3.1.8**
619 **concurrent**
620 occurring or operating at the same time (but not necessarily synchronously)

621 **3.1.9**
622 **conductor wire**
623 **conductor bar**
624 conductive wire or bar of a feeder system with a sliding current collector

625 **3.1.10**
626 **conduit**
627 part of a closed wiring system of circular or non-circular cross-section for insulated conductors
628 and/or cables in electrical installations

629 Note 1 to entry: Conduits should be sufficiently close-jointed so that the insulated conductors and/or cables can
630 only be drawn in and not inserted laterally.

631 [SOURCE: IEC 60050–442:1998, 442-02-03, modified – The definition has been amended and
632 the note has been added.]

633 **3.1.11**
634 **control circuit,**
635 <of a machine> electric circuit (IEV 151-12-01) used for the control, including monitoring, of a
636 machine and/or its electrical equipment (IEV 428-02-07)

637 [SOURCE: IEC 428-01-02]

638 **3.1.12**
639 **control device**
640 <of machinery> device connected into a control circuit and used for controlling the operation of
641 the machine

642 EXAMPLE Position sensor, manual control switch, push-button, relay, contactor, magnetically operated valve,
643 programmable logic controller, touch screen, supervisory controller, networking device.

644 **3.1.13**
645 **control station**
646 **operator control station**
647 assembly of one or more manual operated control devices fixed on the same panel or located
648 in the same enclosure

649 Note 1 to entry: A control station may also contain related equipment, for example, potentiometers, signal lamps,
650 instruments, display devices, etc.

651 [SOURCE: IEC 60050–441:1984, 441-12-08, modified – The second preferred term has been
652 added, the word "control switches" has been replaced by "manually operated control devices"
653 in the definition and the note has been added.]

654 **3.1.14**
655 **controlgear**
656 switching devices and their combination with associated control, measuring, protective, and
657 regulating equipment, also assemblies of such devices and equipment with associated
658 interconnections, accessories, enclosures, and supporting structures, intended in principle for
659 the control of electrical energy consuming equipment

660 [SOURCE: IEC 60050–441:1984, 441-11-03]

661 **3.1.15**
662 **controlled stop**
663 stopping of machine motion with power to the machine actuators maintained during the stopping
664 process

665 **3.1.16**
666 **direct contact**
667 contact of persons or livestock with live parts

668 Note 1 to entry: See [basic protection \(3.1.5\)](#) .

669 [SOURCE: IEC 60050–826:2004, 826-12-03, modified – The note has been added.]

670 **3.1.17**
671 **direct opening action,**
672 <of a contact element> achievement of contact separation as the direct result of a specified
673 movement of the switch actuator through non-resilient members (for example not dependent
674 upon springs)

675 [SOURCE: IEC 60947–5–1:2016, K.2.2]

676 **3.1.18**
677 **duct**
678 enclosed channel designed expressly for holding and protecting electrical conductors, cables,
679 and busbars

680 Note 1 to entry: Conduits (see [conduit \(3.1.10\)](#)), cable trunking systems (see [cable trunking system \(3.1.7\)](#)) and
681 underfloor channels are types of duct.

682 **3.1.19**
683 **earth**
684 **local earth**
685 **ground (US)**
686 **local ground (US)**
687 part of the Earth which is in electric contact with an earth electrode and the electrical potential
688 of which is not necessarily equal to zero

689 [SOURCE: IEC 60050–195:1998,195-01-03]

690 **3.1.20**
691 **electrical operating area**
692 room or location for electrical equipment to which access is intended to be restricted to skilled
693 or instructed persons, by the opening of a door or the removal of a barrier without the use of a
694 key or tool, and which is clearly marked by appropriate warning signs

695 **3.1.21**
696 **electronic equipment**
697 part of the electrical equipment containing circuitry dependent for its operation on electronic
698 devices and components

699 **3.1.22**
700 **emergency stop device**
701 manually actuated control device used to initiate an emergency stop function

702 Note 1 to entry: See [9.2.3.4.2](#).

703 [SOURCE: ISO 13850:2015, 3.3, modified – Note has been added.]

704 **3.1.23**
705 **emergency switching off device**
706 manually actuated control device used to switch off or to initiate the switching off of the supply
707 of electrical energy to all or a part of an installation where a risk of electric shock or another
708 risk of electrical origin is involved

709 Note 1 to entry: See [9.2.3.4.3](#).

710 **3.1.24**
711 **enclosed electrical operating area**
712 room or location for electrical equipment to which access is intended to be restricted to skilled
713 or instructed persons by the use of a key or tool to open a door, or remove a barrier, and which
714 is clearly marked by appropriate warning signs

715 **3.1.25**
716 **enclosure**
717 housing affording the type and degree of protection suitable for the intended application.

718 [SOURCE: IEC 826-12-20]

719 **3.1.26**
720 **electrical equipment**
721 items associated with the utilisation of electricity by machines or parts of machines

722 EXAMPLE material, fittings, devices, components, control gear, appliances, fixtures, apparatus, switchgear, and
723 similar

724 **3.1.27**
725 **equipotential bonding**
726 provision of electric connections between conductive parts, intended to achieve equipotentiality

727 [SOURCE: IEC 60050–195:1998, 195-01-10]

728 **3.1.28**
729 **exposed conductive part**
730 <of electrical equipment> conductive part of electrical equipment, which can be touched and
731 which is not live under normal operating conditions, but which can become live under fault
732 conditions

733 [SOURCE: IEC 60050–826:2004, 826-12-10, modified – The definition has been amended by
734 adding "electrical".]

735 **3.1.29**
736 **extraneous-conductive-part**
737 <In context of electrical equipment> conductive part not forming part of the electrical equipment
738 and liable to introduce an electric potential, generally the electric potential of a local earth

739 [SOURCE: IEC 60050–195:1998, 195-06-11modified – The definition has been amended to
740 replace "installation" with "equipment".]

741 **3.1.30**
742 **failure**
743 termination of the ability of an item to perform a required function

744 Note 1 to entry: After failure, the item has a fault.

745 Note 2 to entry: "Failure" is an event, as distinguished from "fault", which is a state.

746 Note 3 to entry: This concept as defined does not apply to items consisting of software only.

747 Note 4 to entry: In practice, the terms fault and failure are often used synonymously.

748 [SOURCE: IEC 60050–191:1990, 191-04-01]

749 **3.1.31**
750 **fault**
751 state of an item characterized by inability to perform a required function, excluding the inability
752 during preventive maintenance or other planned actions, or due to lack of external resources

753 Note 1 to entry: A fault is often the result of a failure of the item itself, but may exist without prior failure.

754 Note 2 to entry: In English, the term "fault" and its definition are identical with those given in IEC 60050–191:1990,
755 191-05-01. In the field of machinery, the French term "défaut" and the German term "Fehler" are used rather than
756 the terms "panne" and "Fehlzustand" that appear with this definition.

757 **3.1.32**
758 **fault protection**
759 protection against electric shock under single-fault conditions

760 Note 1 to entry: Previously referred to as "protection against indirect contact"

761 [SOURCE: IEC 60050–195:1998, 195-06-02, modified – the Note has been added]

762 **3.1.33**
763 **functional bonding**
764 equipotential bonding necessary for proper functioning of electrical equipment

765 **3.1.34**
766 **hazard**
767 potential source of physical injury or damage to health

768 Note 1 to entry: The term hazard can be qualified in order to define its origin (for example, mechanical hazard,
769 electrical hazard) or the nature of the potential harm (for example, electric shock hazard, cutting hazard, toxic hazard,
770 fire hazard).

771 Note 2 to entry: The hazard envisaged in this definition:
772 either is permanently present during the intended use of the machine (for example motion
773 of hazardous moving elements, electric arc during a welding phase, unhealthy posture,
774 noise emission, high temperature);
775 or can appear unexpectedly (for example: explosion, crushing hazard as a consequence of
776 an unintended/unexpected start-up, ejection as a consequence of a breakage, fall as a
777 consequence of acceleration/deceleration).

778 [SOURCE: ISO 12100:2010, 3.6, modified – The word “harm” has been replaced by “physical
779 injury or damage to health” in the definition and Note 3 has been removed]

780 **3.1.35**
781 **incoming supply**
782 supply to the electrical equipment of the machine coming from the electrical installation

783 **3.1.36**
784 **indirect contact**
785 contact of persons or livestock with exposed conductive parts which have become live under
786 fault conditions

787 Note 1 to entry: See [fault protection \(3.1.32\)](#) .

788 [SOURCE: IEC 60050–826:2004, 826-12-04, modified – The definition has been amended.]

789 **3.1.37**
790 **inductive power supply system**
791 system of inductive power transfer, consisting of a track converter and a track conductor, along
792 which one or more pick-up(s) and associated pick-up converter(s) can move, without any
793 galvanic or mechanical contact, in order to transfer electrical power for example to a mobile
794 machine

795 Note 1 to entry: The track conductor and the pick-up are analogous to the primary and secondary of a transformer
796 respectively.

797 **3.1.38**
798 **instructed person,**
799 <in electricity> person adequately advised or supervised by an electrically skilled person to
800 enable him or her to perceive risks and to avoid hazards which electricity can create

801 [SOURCE: IEC 60050–826:2004, 826-18-02, modified – “an electrically skilled person” has
802 been used to replace “electrically skilled persons”]

803 **3.1.39**
804 **interlock**
805 arrangement of devices operating together to:

806 prevent hazardous situations, or
807 prevent damage to equipment or material, or

808 prevent specified operations, or
809 ensure correct operations

810 **3.1.40**

811 **live part**

812 conductor or conductive part intended to be energized in normal use, including a neutral
813 conductor, but, by convention, not a PEN conductor

814 **3.1.41**

815 **machine actuator**

816 power mechanism of the machine used to effect motion (for example, motor, solenoid,
817 pneumatic or hydraulic cylinder)

818 **3.1.42**

819 **machine**

820 assembly of linked parts or components, at least one of which moves, with the appropriate
821 machine actuators, control and power circuits, joined together for a specific application, in
822 particular for the processing, treatment, moving or packaging of a material

823 Note 1 to entry: The term "machinery" also covers an assembly of machines which, in order to achieve the same
824 end, are arranged and controlled so that they function as an integral whole.

825 Note 2 to entry: The term "component" is used here in a general sense and it does not refer only to electrical
826 components.

827 [SOURCE: ISO 12100:2010, 3.1, modified – The definition has been amended and Note 2
828 referring to an Annex has been removed and replaced by the present Note 2 to entry.]

829 **3.1.43**

830 **marking**

831 signs or inscriptions primarily for the purpose of identifying equipment, components and/or
832 devices

833 **3.1.44**

834 **neutral conductor**

835 **N**

836 conductor electrically connected to the neutral point and capable of contributing to the
837 distribution of electrical energy

838 Note 1 to entry: An earthed conductor of a control circuit supplied by a transformer is not a neutral conductor

839 [SOURCE: SOURCE: IEC 60050-195:1998, 826-14-07, modified - Note 1 added]

840 **3.1.45**

841 **neutral point**

842 common point of a star-connected polyphase system or earthed mid-point of a single-phase
843 system

844 [SOURCE: IEC 826-14-05]

845 **3.1.46**

846 **obstacle**

847 part preventing unintentional direct contact with live parts, but not preventing direct contact by
848 deliberate action

849 [SOURCE: IEC 60050-195:1998, 195-06-16, modified – The words "(electrically) protective"
850 have been removed from the term.]

851 **3.1.47**
852 **overcurrent**
853 current exceeding the rated value

854 Note 1 to entry: For conductors, the rated value is considered as equal to the current-carrying capacity.

855 [SOURCE: IEC 60050–826:2004, 826-11-14, modified – The definition has been amended.]

856 **3.1.48**
857 **overload of a circuit**
858 time/current relationship in a circuit which is in excess of the rated full load of the circuit when
859 the circuit is not under a fault condition

860 Note 1 to entry: Overload should not be used as a synonym for overcurrent.

861 **3.1.49**
862 **plug/socket combination**
863 component and a suitable mating component, appropriate to terminate conductors, intended for
864 connection or disconnection of two or more conductors

865 Note 1 to entry: Examples of plug/socket combination include:

866 connectors which fulfil the requirements of IEC 61984;
867 a plug and socket-outlet, a cable coupler, or an appliance coupler in accordance with
868 IEC 60309–1;
869 a plug and socket-outlet in accordance with IEC 60884–1 or an appliance coupler in
870 accordance with IEC 60320–1.

871 **3.1.50**
872 **power circuit**
873 circuit that supplies power to units of equipment used for productive operation and to
874 transformers or power supplies supplying control circuits

875 **3.1.51**
876 **prospective short-circuit current**
877 **I_{cp}**
878 r.m.s. value of the current which would flow when the supply conductors to the electrical
879 equipment are short-circuited by a conductor of negligible impedance located as near as
880 practicable to the supply terminals of the electrical equipment

881 [SOURCE: IEC 61439–1: 2011, 3.8.7, modified – “assembly” has been replaced by “electrical
882 equipment”]

883 **3.1.52**
884 **protective bonding**
885 equipotential bonding for protection against electric shock

886 Note 1 to entry: Measures for protection against electric shock can also reduce the risk of burns or fire.

887 Note 2 to entry: Protective bonding can be achieved with protective conductors and protective bonding conductors
888 and by conductive joining of conductive parts of the machine and its electrical equipment.

889 **3.1.53**
890 **protective bonding circuit**
891 electric circuit consisting of protective conductors and conductive parts connected together to
892 provide protection against electric shock

893 **3.1.54**
894 **protective conductor**
895 conductor providing a primary fault current path from the exposed conductive parts of the
896 electrical equipment to a protective earthing (PE) terminal

897 **3.1.55**
898 **redundancy**
899 application of more than one device or system, or part of a device or system, with the objective
900 of ensuring that in the event of one failing to perform its function, another is available to perform
901 that function

902 **3.1.56**
903 **reference designation**
904 distinctive code which serves to identify an object in the documentation and on the equipment

905 **3.1.57**
906 **risk**
907 combination of the probability of occurrence of harm (i.e. physical injury or damage to health)
908 and the severity of that harm

909 [SOURCE: ISO 12100:2010, 3.12, modified – The text in parentheses has been added]

910 **3.1.58**
911 **safeguard**
912 guard or protective device provided as a means to protect persons from a hazard

913 [SOURCE: ISO 12100:2010, 3.26, modified – The words “provided as a means to protect
914 persons from a hazard” have been added.]

915 **3.1.59**
916 **safeguarding**
917 protective measure using safeguards to protect persons from the hazards which cannot
918 reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently
919 safe design measures

920 [SOURCE: ISO 12100:2010, 3.21]

921 **3.1.60**
922 **safety function**
923 function of a machine whose failure can result in an immediate increase of the risk(s)

924 [SOURCE: ISO 12100:2010, 3.30; IEC 62061:2005, 3.2.15]

925 **3.1.61**
926 **servicing level**
927 plane at which persons operate or maintain the electrical equipment

928 EXAMPLE Floor level, platform level

929 **3.1.62**
930 **short-circuit current**
931 overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric
932 circuit

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

934 **3.1.63**
935 **short-circuit current rating**
936 value of prospective short-circuit current that can be withstood by the electrical equipment for
937 the total operating time (clearing time) of the short-circuit protective device (SCPD) under
938 specified conditions

939 [SOURCE: IEC 61439–1: 2011, 3.8.10.4, modified – The word “rated” is removed from the term,
940 and the reference to “assembly” removed from the definition.]

941 **3.1.64**
942 **skilled person**
943 **electrically skilled person**
944 person with relevant training, education and experience to enable him or her to perceive risks
945 and to avoid hazards associated with electricity

946 [SOURCE: IEC 60050–826:2004, 826-18-01, modified – The parentheses have been removed
947 and “training” has been added.]

948 **3.1.65**
949 **supplier**
950 entity (for example manufacturer, contractor, installer, integrator) who provides equipment or
951 services associated with the machine

952 Note 1 to entry: The user organization may also act in the capacity of a supplier to itself.

953 **3.1.66**
954 **switching device**
955 device designed to make and/or break the current in one or more electric circuits

956 Note 1 to entry: A switching device may perform one or both of these actions.

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

958 **3.1.67**
959 **uncontrolled stop**
960 stopping of machine motion by removing electrical power to the machine actuators

961 Note 1 to entry: This definition does not imply any particular state of other stopping devices, for example mechanical
962 or hydraulic brakes.

963 **3.1.68**
964 **user**
965 entity who utilizes the machine and its associated electrical equipment

966 **3.2 Abbreviated terms**

967 AC

968 Alternating Current

969 AWG

970 American Wire Gauge

971 BDM

972 Basic Drive Module

973 CCS

974 Cableless Control System

975 DC

976 Direct Current

977	EMC
978	Electro-Magnetic Compatibility
979	EMI
980	Electro-Magnetic Interference
981	IFLS
982	Insulation Fault Location System
983	MMI
984	Man-Machine interface
985	PDS
986	Power Drive System
987	PELV
988	Protective Extra-Low Voltage
989	RCD
990	Residual Current protective Device
991	SCPD
992	Short-Circuit Protective Device
993	SELV
994	Safe Extra-Low Voltage
995	SLP
996	Safely-Limited Position
997	SPD
998	Surge Protective Devices
999	STO
1000	Safe Torque Off

1001 **4 General requirements**

1002 **4.1 General**

1003 This standard specifies requirements for the electrical equipment of machines.

1004 The risks associated with the hazards relevant to the electrical equipment shall be assessed as
1005 part of the overall requirements for risk assessment of the machine. This will:

- 1006 identify the need for risk reduction; and
- 1007 determine adequate risk reductions; and
- 1008 determine the necessary protective measures

1009 for persons who can be exposed to those hazards, while still maintaining an appropriate
1010 performance of the machine and its equipment.

1011 Hazardous situations can result from, but are not limited to, the following causes:

- 1012 failures or faults in the electrical equipment resulting in the possibility of electric shock, arc,
1013 or fire;
- 1014 failures or faults in control circuits (or components and devices associated with those
1015 circuits) resulting in the malfunctioning of the machine;
- 1016 disturbances or disruptions in power sources as well as failures or faults in the power circuits
1017 resulting in the malfunctioning of the machine;

1018 loss of continuity of circuits that can result in a failure of a safety function, for example those
1019 that depend on sliding or rolling contacts;
1020 electrical disturbances for example, electromagnetic, electrostatic either from outside the
1021 electrical equipment or internally generated, resulting in the malfunctioning of the machine;
1022 release of stored energy (either electrical or mechanical) resulting in, for example, electric
1023 shock, unexpected movement that can cause injury;
1024 acoustic noise and mechanical vibration at levels that cause health problems to persons;
1025 surface temperatures that can cause injury.

1026 Safety measures are a combination of the measures incorporated at the design stage and those
1027 measures required to be implemented by the user.

1028 The design and development process shall identify hazards and the risks arising from them.
1029 Where the hazards cannot be removed and/or the risks cannot be sufficiently reduced by
1030 inherently safe design measures, protective measures (for example safeguarding) shall be
1031 provided to reduce the risk. Additional means (for example, awareness means) shall be
1032 provided where further risk reduction is necessary. In addition, working procedures that reduce
1033 risk can be necessary.

1034 It is recommended that, where the user is known, [Annex B](#) be used to facilitate an exchange of
1035 information between the user and the supplier(s) on basic conditions and additional user
1036 specifications related to the electrical equipment.

1037 Those additional specifications can:

1038 provide additional features that are dependent on the type of machine (or group of
1039 machines) and the application;
1040 facilitate maintenance and repair; and
1041 improve the reliability and ease of operation.

1042 **4.2 Selection of equipment**

1043 **4.2.1 General**

1044 Electrical components and devices shall:

1045 be suitable for their intended use; and
1046 conform to relevant IEC standards where such exist; and
1047 be applied in accordance with the supplier's instructions.

1048 **4.2.2 Switchgear**

1049 In addition to the requirements of IEC 60204–1, depending upon the machine, its intended use
1050 and its electrical equipment, the designer may select parts of the electrical equipment of the
1051 machine that are in compliance with relevant parts of the IEC 61439 series (see also [Annex F](#)).

1052 **4.2.3 Power Drive Systems**

1053 In addition to the requirements of IEC 60204-1, depending upon the machine, its intended use
1054 and its electrical equipment, the designer may select parts of the electrical equipment of the
1055 machine that are in compliance with relevant parts of the IEC 61800 series (see also Annex F).

1056 **4.3 Electrical supply**

1057 **4.3.1 General**

1058 The electrical equipment shall be designed to operate correctly with the conditions of the supply:

1059 as specified in 4.3.2 or 4.3.3, or
1060 as specified by the supplier of a special source of supply (see 4.3.4), or
1061 as otherwise specified by the user.

1062 Possibility of reduced performance should be considered for the conditions given in 4.3.2 - 4.3.4
1063 for electrical equipment including PDS.

1064 Overvoltage category of electrical equipment shall be specified.

1065 **4.3.2 AC supplies**

Voltage	Steady state voltage: 0,9 to 1,1 of nominal voltage.
Frequency	0,99 to 1,01 of nominal frequency continuously; 0,98 to 1,02 short time.
Harmonics	Harmonic distortion not exceeding 12 % of the total r.m.s. voltage between live conductors for the sum of the 2nd through to the 30th harmonic.
Voltage unbalance	Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies exceeding 2 % of the positive sequence component.
Voltage interruption	Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle with more than 1 s between successive interruptions.
Voltage dips	Voltage dips not exceeding 20 % of the rms voltage of the supply for more than one cycle with more than 1 s between successive dips.

1066 **4.3.3 DC supplies**

1067 From batteries:

Voltage	0,85 to 1,15 of nominal voltage; 0,7 to 1,2 of nominal voltage in the case of battery-operated vehicles.
Voltage interruption	Not exceeding 5 ms.

1068 From converting equipment:

Voltage	0,9 to 1,1 of nominal voltage.
Voltage interruption	Not exceeding 20 ms with more than 1 s between successive interruptions.
Ripple (peak-to-peak)	Not exceeding 0,15 of nominal voltage.

1069 **4.3.4 Special supply systems**

1070 For special supply systems (e.g. on-board generators, DC bus, etc.) the limits given in 4.3.2
1071 and 4.3.3 may be different provided that the equipment is designed to operate correctly with
1072 those conditions.

1073 **4.4 Physical environment and operating conditions**

1074 **4.4.1 General**

1075 The electrical equipment shall be suitable for the physical environment and operating
1076 conditions:

1077 as specified in 4.4.2 through 4.4.7

1078 as otherwise specified by the user.

1079 **4.4.2 Ambient air temperature**

1080 Electrical equipment shall be capable of operating correctly in the intended ambient air
1081 temperature. The minimum requirement for all electrical equipment is correct operation in
1082 ambient air temperatures outside of enclosures (cabinet or box) between +5 °C and +40 °C.

1083 **4.4.3 Humidity**

1084 The electrical equipment shall be capable of operating correctly when the relative humidity does
1085 not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities are permitted
1086 at lower temperatures (for example 90 % at 20 °C).

1087 Harmful effects of occasional condensation shall be avoided by design of the equipment or,
1088 where necessary, by additional measures (for example built-in heaters, air conditioners, drain
1089 holes).

1090 **4.4.4 Altitude**

1091 Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m above
1092 mean sea level.

1093 For equipment to be used at higher altitudes, it is necessary to take into account changes in
1094 parameters for example, the reduction of:

1095 the dielectric strength, and;

1096 the switching capability of the devices, and;

1097 the cooling effect of the air.

1098 Other parameters of different components can also alter with altitude. It is recommended that
1099 the manufacturer is consulted regarding the correction factors to be used where the factors are
1100 not specified in product data.

1101 **4.4.5 Contaminants**

1102 Electrical equipment shall be adequately protected against the ingress of solids and liquids (see
1103 [11.3](#)).

1104 The electrical equipment shall be adequately protected against contaminants (for example dust,
1105 acids, corrosive gases, salts) that can be present in the physical environment in which the
1106 electrical equipment is to be installed.

1107 **4.4.6 Ionizing and non-ionizing radiation**

1108 Where electrical equipment is subject to radiation (for example microwave, ultraviolet (UV),
1109 lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the electrical
1110 equipment and accelerated deterioration of the insulation.

1111 **4.4.7 Vibration, shock, and bump**

1112 Undesirable effects of vibration, shock and bump (including those generated by the machine
1113 and its associated equipment and those created by the physical environment) shall be avoided
1114 by the selection of suitable equipment, by mounting it away from the machine, or by provision
1115 of anti-vibration mountings.

1116 4.5 Transportation and storage

1117 Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to
1118 protect against, the effects of transportation and storage temperatures within a range of $-25\text{ }^{\circ}\text{C}$
1119 to $+55\text{ }^{\circ}\text{C}$ and for short periods not exceeding 24 h at up to $+70\text{ }^{\circ}\text{C}$. Suitable means shall be
1120 provided to prevent damage from humidity, vibration, and shock.

1121 Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

1122 4.6 Provisions for handling

1123 Heavy and bulky electrical equipment that has to be removed from the machine for transport,
1124 or that is independent of the machine, shall be provided with suitable means for handling,
1125 including where necessary means for handling by cranes or similar equipment.

1126 4.7 Electromagnetic compatibility (EMC)

1127 The electrical equipment shall not generate electromagnetic disturbances above levels that are
1128 appropriate for its intended operating environment. In addition, the electrical equipment shall
1129 have a sufficient level of immunity to electromagnetic disturbances so that it can function in its
1130 intended environment.

1131 With regard to immunity and emission of the electrical equipment, the applicable levels and
1132 limits shall be observed.

1133 An EMC risk assessment shall be carried out to identify all relevant phenomena, taking into
1134 account the intended use of the electrical equipment and the resulting EMC environment (e. g.
1135 industrial or residential). Product standards include such a risk assessment. Measures
1136 resulting from the risk assessment can be implemented either directly on the electrical
1137 equipment itself or when installed on the complete machine.

1138 Where details of the applicable EMC requirements are set out in product-specific EMC
1139 standards and generic standards, the product standard shall prevail. If product standards do
1140 not exist, generic standards can be applied based on the risk assessment. In this case, the
1141 manufacturer shall document the rationale on which he selected the phenomena and the defined
1142 immunity level and emission limits.

1143 The generic EMC standards IEC 61000-6-1 or IEC 61000-6-2 and IEC 61000-6-3 or IEC 61000-
1144 6-4 give general EMC emission and immunity limits. EMC requirements for specific devices
1145 used in electrical equipment of machinery can be given in an EMC product standard (for
1146 example IEC 61800-3)

1147 Annex H provides examples of measures to reduce the effects of electromagnetic influences.

1148 5 Incoming supply conductor terminations and devices for disconnecting and 1149 switching off

1150 5.1 Incoming supply conductor terminations

1151 It is recommended that, where practicable, the electrical equipment of a machine is connected
1152 to a single incoming supply. Where another supply is necessary for certain parts of the
1153 equipment (for example, electronic equipment that operates at a different voltage), that supply
1154 should be derived, as far as is practicable, from devices (for example, transformers, converters)
1155 forming part of the electrical equipment of the machine. For large complex machinery there can
1156 be a need for more than one incoming supply depending upon the site supply arrangements
1157 (see 5.3.1).

1158 Unless a plug is provided with the machine for the connection to the [incoming supply \(3.1.35\)](#)
1159 (see [5.3.2 e\)](#)), it is recommended that the supply conductors are terminated at the supply
1160 disconnecting device. Where the incoming supply conductors do not terminate at the supply
1161 disconnecting device, live parts between the terminations of the incoming supply and the supply
1162 disconnecting device shall be separated from other circuits and shall comply with one or more
1163 of the following identification methods:

1164 by the colour ORANGE throughout the length of the conductor either by the colour of the
1165 insulation or by colour markers at the ends and where accessible, at regular intervals; or
1166 by permanent warning label(s) at the ends and where accessible, at regular intervals.

1167 The warning label and explanation of method used to identify these circuits shall be included in
1168 the information on maintenance.

1169 Where a neutral conductor is used it shall be clearly indicated in the technical documentation
1170 of the machine, such as in the installation diagram and in the circuit diagram. A separate
1171 insulated terminal, labelled N in accordance with IEC 60445, shall be provided for the neutral
1172 conductor. The neutral terminal may be provided as part of the supply disconnecting device.

1173 There shall be no connection between the neutral conductor and the protective bonding circuit
1174 inside the electrical equipment.

1175 Exception: a connection may be made between the neutral terminal and the PE terminal at the
1176 point of the connection of the electrical equipment to a TN-C supply system.

1177 For machines supplied from parallel sources, the requirements of IEC 60364–1 for multiple
1178 source systems apply.

1179 Terminals for the incoming supply connections shall be clearly identified in accordance with
1180 IEC 60445. The terminal for the external protective conductor shall be identified in accordance
1181 with [5.2](#).

1182 **5.2 Terminal for connection of the external protective conductor**

1183 For each incoming supply, a terminal or a tap-off-point from the main earthing busbar (<195-
1184 02-33>) shall be provided in the same compartment as the associated line conductor terminals
1185 for connection of the machine to the external protective conductor.

1186 The terminal shall be of such a size as to enable the connection of an external protective copper
1187 conductor with a cross-sectional area determined in relation to the size of the associated line
1188 conductors in accordance with [Table 1](#).

1189 **Table 1 – Minimum cross-sectional area of copper protective conductors**

Cross-sectional area of line conductors S	Minimum cross-sectional area of the corresponding protective conductor (PE) S_p
mm^2	mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S \leq 400$	$S/2$
$400 < S \leq 800$	200
$800 < S$	$S/4$

1190 Where an external protective conductor of a material other than copper is used, the terminal
1191 size and type shall be selected accordingly.

1192 At each incoming supply point, the terminal for connection of external protective conductor shall
1193 be marked or labelled with the letters PE (see IEC 60445 Table A.1). Where the letters PE are
1194 used to identify other protective conductor terminals, an additional reference designation on the
1195 external protective conductor terminal shall be used to uniquely identify the external protective
1196 conductor terminal.

1197 **5.3 Supply disconnecting (isolating) device**

1198 **5.3.1 General**

1199 A supply disconnecting device shall be provided:

1200 for each incoming supply to (a) machine(s);

1201 The incoming supply can be connected directly to the supply disconnecting device of the
1202 machine or to the supply disconnecting device of a feeder system of the machine. Feeder
1203 systems of machines can include conductor wires, conductor bars, slip-ring assemblies,
1204 flexible cable systems (reeled, festooned) or inductive power supply systems.

1205 for the outgoing supply of each internal power source (e.g. UPS, generator, battery, solar
1206 panel).

1207 The supply disconnecting device shall disconnect (isolate) the electrical equipment of the
1208 machine from the supply when required (for example for work on the machine, including the
1209 electrical equipment).

1210 Where two or more supply disconnecting devices are provided, protective interlocks for their
1211 correct operation shall also be provided in order to prevent a hazardous situation.

1212 **5.3.2 Type**

1213 The supply disconnecting device shall be one of the following types:

- 1214 switch-disconnector, with or without fuses, in accordance with IEC 60947–3, utilization
1215 category [AC-23A](#), [AC-23Ae](#), [AC-23B](#), [AC-23-B3](#), [DC-23A](#), or [DC-23B](#);
- 1216 control and protective switching device suitable for isolation, in accordance with IEC 60947–
1217 6–2;
- 1218 a circuit-breaker suitable for isolation in accordance with IEC 60947–2;
- 1219 any other switching device in accordance with an IEC product standard for that device and
1220 which meets the isolation requirements and the appropriate utilization category and/or
1221 specified endurance requirements defined in the product standard;
- 1222 a plug that is part of a plug/socket combination for a flexible cable connection to the supply.

1223 5.3.3 Requirements

- 1224 The supply disconnecting device shall have a breaking capacity sufficient to interrupt the
1225 current of the largest motor when stalled together with the sum of the normal running currents
1226 of all other motors and other loads. The calculated breaking capacity may be reduced by the
1227 use of a proven diversity factor. Where motor(s) are supplied by converter(s) or similar devices,
1228 the calculation should take into account the possible effect on the required breaking capacity

- 1229 Where the supply disconnecting device is one of the types specified in [5.3.2 a\) \(a\)\) \(a\)\)](#) to [\(d\)\) \(d\)\)](#) it shall fulfil all of the following requirements:

- 1231 isolate the electrical equipment from the supply and have one OFF (isolated) and one ON
1232 position marked with "O" and "I" (symbols IEC 60417–5008 (2002-10) and IEC 60417–5007
1233 (2002-10), see [10.2.2](#));
- 1234 have a visible contact gap or a position indicator which cannot indicate OFF (isolated) until
1235 all contacts are actually open and the requirements for the isolating function have been
1236 satisfied;
- 1237 have an operating means (see [5.3.4](#));
- 1238 be provided with a means permitting it to be locked in the OFF (isolated) position (for
1239 example by padlocks). When so locked, remote as well as local closing shall be prevented;
- 1240 disconnect all live conductors of its power supply circuit. However, for TN supply systems,
1241 the neutral conductor may or may not be disconnected except in countries where
1242 disconnection of the neutral conductor (when used) is compulsory;

- 1243 Where the supply disconnecting device is a plug that is part a plug/socket combination, the plug
1244 /socket combination shall comply with the requirements of [13.4.5](#) pertaining to plug/socket
1245 combinations intended to connect and disconnect under load conditions.

- 1246 A suitably rated plug and socket-outlet, cable coupler, or appliance coupler, in accordance with
1247 IEC 60309–1 can fulfil these requirements.

- 1248 Where the supply disconnecting device is a plug/socket combination, a switching device with
1249 an appropriate utilisation category shall be provided for switching the machine on and off.

1250 5.3.4 Operating means of the supply disconnecting device

- 1251 The operating means (for example, a handle) of the supply disconnecting device shall be
1252 external to the enclosure of the electrical equipment.

- 1253 Exception: power-operated switchgear need not be provided with a handle outside the
1254 enclosure where other means (e.g. pushbuttons) are provided to open the supply disconnecting
1255 device from outside the enclosure.

- 1256 The operating means of the supply disconnecting device shall be readily accessible and located
1257 between 0,6 m and 1,9 m above its servicing level. An upper limit of 1,7 m is recommended.

- 1258 The direction of operation is given in IEC 61310–3.

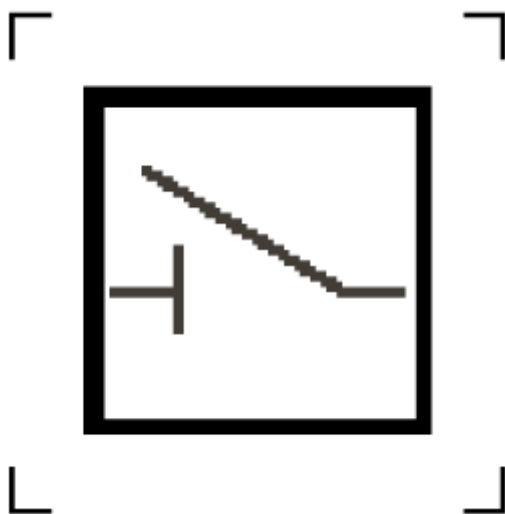
1259 Where the external operating means is intended for emergency operation, see 10.7.3 or 10.8.3.

1260 Where the external operating means is not intended for emergency operations:

1261 it is recommended that it be coloured BLACK or GREY (see 10.2)

1262 a supplementary cover or door that can be readily opened without the use of a key or tool
1263 may be provided, for example for protection against environmental conditions or mechanical
1264 damage. Such a cover/door shall clearly show that it provides access to the operating
1265 means. This can be achieved, for example, by use of a transparent cover or use of the
1266 relevant symbol IEC 60417-6169-1 (2012-08) (Figure 2) or IEC 60417-6169-2 (2012-08),
1267 (Figure 3).

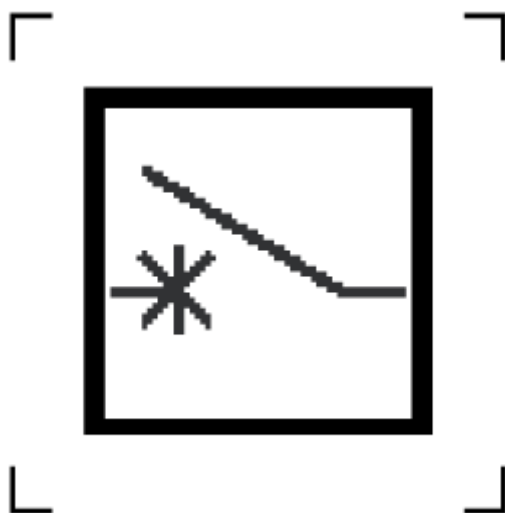
1268



1269

1270 **Figure 2 – Disconnector isolator**

1271



1272

1273 **Figure 3 – Disconnecting circuit breaker**

1274 5.3.5 Excepted circuits

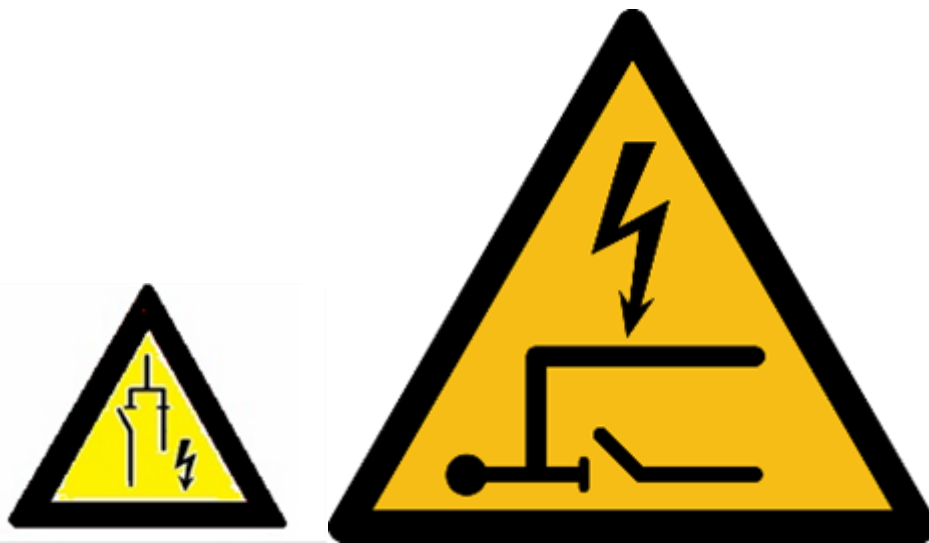
1275 The following circuits need not be disconnected by the supply disconnecting device:

- 1276 lighting circuits for lighting needed during maintenance or repair;
- 1277 socket outlets for the exclusive connection of repair or maintenance tools and equipment
- 1278 (for example hand drills, test equipment) (see 15.1);
- 1279 undervoltage protection circuits that are only provided for automatic tripping in the event of
- 1280 supply failure;
- 1281 circuits supplying equipment that should normally remain energized for correct operation
- 1282 (for example temperature controlled measuring devices, heaters, program storage devices);
- 1283 control circuits supplied via another supply disconnecting device, regardless of whether that
- 1284 disconnecting device is located in the electrical equipment or in another machine or other
- 1285 electrical equipment.

1286 I However, where required by the risk assessment, such circuits shall be provided with suitably
1287 located device(s) for isolation (e.g. for electrical maintenance).

1288 Where excepted circuits are not disconnected by the supply disconnecting device:

- 1289 the following permanent warning label(s) shall be appropriately placed in proximity to the
- 1290 operating means of the supply disconnecting device to draw attention to the hazard
- 1291 CAUTION: Not all circuits are disconnected by this supply disconnecting device."



- 1292
- 1293 CHECK ISO 3864-2 and IEC 61310-3 for wording and/or symbol;
- 1294 a corresponding statement shall be included in the maintenance manual, and one or more
- 1295 of the following shall apply:
- 1296 The warning label statement and explanation of method used to identify excepted circuits
- 1297 shall be included in the information on maintenance.

1298 5.4 Devices for removal of power for prevention of unexpected start-up

- 1299 Devices for removal of power for the prevention of unexpected start-up shall be provided where
- 1300 a start-up of the machine or part of the machine can create a hazard (for example during
- 1301 maintenance). Such devices shall be appropriate and convenient for the intended use, be
- 1302 suitably placed, and readily identifiable as to their function and purpose. Where their function
- 1303 and purpose is not otherwise obvious (e.g. by their location) these devices shall be marked to
- 1304 indicate the extent of removal of power.

1305 This part of IEC 60204 does not address all provisions for prevention of unexpected start up.
1306 Further information is provided in ISO 14118.

1307 Removal of power means removal of the connection to the source of electrical energy but does
1308 not imply isolation.

1309 The supply disconnecting device or other devices in accordance with 5.3.2 may be used for
1310 prevention of unexpected start-up.

1311 Disconnectors, withdrawable fuse links and withdrawable links may be used for protection of
1312 unexpected start-up only if they are located in an enclosed electrical operating area (see
1313 enclosed electrical operating area (3.1.24)).

1314 Devices that do not fulfil the isolation function (for example a contactor switched off by a control
1315 circuit, or Power Drive System (PDS) with a Safe Torque Off (STO) function in accordance with
1316 IEC 61800–5–2) may only be used for prevention of unexpected start-up during tasks such as:

1317 inspections;

1318 adjustments;

1319 work on the electrical equipment where:

1320 The selection of a device will be dependent on the risk assessment.

1321 5.5 Devices for isolating electrical equipment

1322 Devices shall be provided for isolating (disconnecting) the electrical equipment or part(s) of the
1323 electrical equipment to enable work on the electrical equipment to be carried out when it is de-
1324 energised and isolated. Such devices shall be:

1325 appropriate and convenient for the intended use;

1326 suitably placed;

1327 readily identifiable as to which part(s) or circuit(s) of the equipment is served. Where their
1328 function and purpose is not otherwise obvious (e.g. by their location) these devices shall be
1329 marked to indicate the extent of the equipment that they isolate.

1330 The supply disconnecting device (see 5.3) may, in some cases, fulfil that function. However,
1331 where it is necessary to work on individual parts of the electrical equipment of a machine, or on
1332 one of the machines fed by a common conductor bar, conductor wire or inductive power supply
1333 system, a disconnecting device shall be provided for each part, or for each machine, requiring
1334 separate isolation.

1335 In addition to the supply disconnecting device, the following devices that fulfil the isolation
1336 function may be provided for this purpose:

1337 devices described in 5.3.2;

1338 disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed
1339 electrical operating area (see enclosed electrical operating area (3.1.24)) and relevant
1340 information is provided with the electrical equipment (see Clause 17).

1341 5.6 Protection against unauthorized, inadvertent and/or mistaken connection

1342 Where the devices described in 5.4 and 5.5 are located outside an enclosed electrical operating
1343 area they shall be equipped with means to secure them in the OFF position (disconnected
1344 state), (for example by provisions for padlocking, trapped key interlocking). When so secured,
1345 remote as well as local reconnection shall be prevented.

1346 Where the devices described in 5.4 and 5.5 are located inside an enclosed electrical operating
1347 area other means of protection against reconnection (for example warning labels) can be
1348 sufficient.

1349 However, when a plug/socket combination according to [5.3.2 e\) \(e\)](#) is so positioned that it
1350 can be kept under the immediate supervision of the person carrying out the work, means for
1351 securing in the disconnected state need not be provided.

1352 **6 Protection against electric shock**

1353 **6.1 General**

1354 The electrical equipment shall provide protection of persons against electric shock by:

1355 basic protection (see [6.2](#) and [6.4](#)), and;

1356 fault protection (see [6.3](#) and [6.4](#)).

1357 The measures for protection given in [6.2](#), [6.3](#), and, for [PELV](#), in [6.4](#), are a selection from
1358 IEC 60364–4–41. Where those measures are not practicable, for example due to the physical
1359 or operational conditions, other measures from IEC 60364–4–41 may be used (e.g. [SELV](#)).

1360 See IEC 60364-7 series for additional information for equipment intended for use in special
1361 installations or locations.

1362 **6.2 Basic protection**

1363 **6.2.1 General**

1364 For each circuit or part of the electrical equipment, the measures of either [6.2.2](#) or [6.2.3](#) and,
1365 where applicable, [6.2.4](#) shall be applied.

1366 Exception: where those measures are not appropriate, other measures for basic protection (for
1367 example by using barriers, by placing out of reach, using obstacles, using construction or
1368 installation techniques that prevent access) as defined in IEC 60364–4–41 may be applied (see
1369 also [6.2.5](#) and [6.2.6](#)).

1370 Where the equipment is located in places open to all persons, which can include children,
1371 measures of either [6.2.2](#) with a minimum degree of protection against contact with live parts
1372 corresponding to IP4X or IPXXD (see IEC 60529), or [6.2.3](#) shall be applied.

1373 **6.2.2 Protection by enclosures**

1374 Live parts shall be located inside enclosures that provide protection against contact with live
1375 parts of at least IP2X or IPXXB (see IEC 60529).

1376 Where the top surfaces of an enclosure, having a height lower than 2,5 m above the servicing
1377 level, are readily accessible, the minimum degree of protection against contact with live parts
1378 provided by the top surfaces shall be IP4X or IPXXD.

1379 Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only
1380 under one or more of the following conditions:

1381 The use of a key or tool is necessary for access.

1382 The requirement to use a key or tool is intended to restrict access only to skilled or instructed
1383 persons (see [f](#)) and to prevent access by use of improvised implements (e.g. coin, nail-file)..

1384 All live parts located inside enclosures (including those mounted on the internal surface of
1385 doors) likely to be touched or in the immediate vicinity of device actuators intended to be
1386 operated for reset or adjustments while the equipment is still connected shall be protected
1387 against contact to at least IP2X or IPXXB. Other live parts within the expected approach
1388 paths to such devices and all live parts mounted on the internal surface of doors shall be
1389 protected against unintentional direct contact to at least IP1X or IPXXA or by barriers or
1390 obstacles.

1391 The disconnection of live parts inside the enclosure before the enclosure can be opened.
1392 This may be accomplished by interlocking the door with a disconnecting device (for example,
1393 the supply disconnecting device) so that the door can only be opened when the
1394 disconnecting device is open and so that the disconnecting device can only be closed when
1395 the door is closed.

1396 Exception: a key or tool as prescribed by the supplier can be used to defeat the interlock
1397 provided that the following conditions are met:

1398 All parts that are still live after switching off the disconnecting device(s) (see 5.3.5) shall be
1399 protected against direct contact to at least IP2X or IPXXB (see IEC 60529). Such parts shall
1400 be marked with a warning sign in accordance with 16.2.1 (see also 13.2.4 for identification
1401 of conductors by colour), except for:

1402 Opening without the use of a key or a tool and without disconnection of live parts shall be
1403 possible only when all live parts are protected against contact to at least IP2X or IPXXB
1404 (see IEC 60529). Where barriers provide this protection, either they shall require a tool for
1405 their removal or all live parts protected by them shall be automatically disconnected when
1406 the barrier is removed. Where a hazard can be caused by manual actuation of devices (for
1407 example manual closing of contactors or relays), such actuation shall be prevented by
1408 barriers that require a tool for their removal.

1409 The requirement to use a tool for removal of barriers is intended to restrict only to skilled or
1410 instructed persons (see 17.2 f)) and to prevent removal by use of improvised implements
1411 (e.g. coin, nail-file).

1412 6.2.3 Protection by insulation of live parts

1413 Live parts protected by insulation shall be completely covered with insulation that can only be
1414 removed by destruction. Such insulation shall be capable of withstanding the mechanical,
1415 chemical, electrical, and thermal stresses to which it can be subjected under normal operating
1416 conditions.

1417 Paints, varnishes, lacquers, and similar products alone are generally considered to be
1418 inadequate for protection against electric shock under normal operating conditions.

1419 6.2.4 Protection against residual voltages

1420 Live parts having a residual voltage greater than 60 V when the supply is disconnected shall
1421 be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge
1422 does not interfere with the proper functioning of the equipment. Exempted from this requirement
1423 are live parts connected to components having a stored charge of 60 µC or less. Where this
1424 specified rate of discharge would interfere with the proper functioning of the equipment, a
1425 durable warning notice drawing attention to the hazard and stating the delay required before
1426 the enclosure may be opened shall be displayed at an easily visible location on or immediately
1427 adjacent to the enclosure that contains the live parts.

1428 In the case of plugs or similar devices, the withdrawal of which results in the exposure of
1429 conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such
1430 conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor
1431 a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable
1432 collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional
1433 switching devices or an appropriate warning, for example a warning sign drawing attention to
1434 the hazard and stating the delay required shall be provided. When the equipment is located in
1435 places open to all persons, which can include children, warnings are not sufficient and therefore
1436 a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

1437 Frequency converters and DC bus supplies could have typically a longer discharge time than
1438 5 s.

1439 **6.2.5 Protection by barriers**

1440 For protection by barriers, the requirements of IEC 60364–4–41 shall apply.

1441 **6.2.6 Protection by placing out of reach or protection by obstacles**

1442 For protection by placing out of reach or protection by obstacles, the requirements of
1443 IEC 60364–4–41 shall apply.

1444 For conductor wire systems or conductor bar systems with a degree of protection less than
1445 IP2X or IPXXB, see [12.7.1](#).

1446 **6.3 Fault protection**

1447 **6.3.1 General**

1448 [fault protection \(3.1.32\)](#) is intended to prevent hazardous situations due to an insulation fault
1449 between live parts and exposed conductive parts.

1450 For each circuit or part of the electrical equipment, at least one of the measures in accordance
1451 with [6.3.2](#) to [6.3.3](#) shall be applied:

1452 measures to prevent the occurrence of a touch voltage ([6.3.2](#)); or

1453 automatic disconnection of the supply before the time of contact with a touch voltage can
1454 become hazardous ([6.3.3](#)).

1455 The risk of harmful physiological effects from touch voltages depends upon a number of factors.
1456 These include but are not limited to; value of touch voltage, duration of possible exposure,
1457 environmental factors, skin condition.

1458 IEC 61140 provides information about classes of equipment and protective provisions.

1459 Where a power drive system (PDS) is provided, fault protection shall be provided for those
1460 circuits of the power drive system that are supplied by the converter. Where this protection is
1461 not provided within the converter, the necessary protection measures shall be in accordance
1462 with the converter manufacturer's instructions.

1463 **6.3.2 Prevention of the occurrence of a touch voltage**

1464 **6.3.2.1 General**

1465 Measures to prevent the occurrence of a touch voltage include the following:

1466 provision of class II equipment or by equivalent insulation;

1467 electrical separation.

1468 **6.3.2.2 Protection by provision of class II equipment or by equivalent insulation**

1469 This measure is intended to prevent the occurrence of touch voltages on the accessible parts
1470 through a fault in the basic insulation.

1471 This protection is provided by one or more of the following:

1472 class II electrical devices or apparatus (double insulation, reinforced insulation or by
1473 equivalent insulation in accordance with IEC 61140);

1474 switchgear and controlgear assemblies having total insulation in accordance with
1475 IEC 61439–1;

1476 double or reinforced insulation in accordance with IEC 60364–4–41:2005 Clause 412;

1477 wiring systems installed in accordance with IEC 60364–5–52:2009 in electrical systems with
1478 nominal voltages not higher than 690 V, are considered to meet the requirements for basic
1479 protection and fault protection (IEC 60364–4–41:2005 Par. 412.2) if the following cables or
1480 insulated conductors are used:

1481 **6.3.2.3 Protection by electrical separation**

1482 Electrical separation of an individual circuit is intended to prevent a touch voltage through
1483 contact with exposed conductive parts that can be energized by a fault in the basic insulation
1484 of the live parts of that circuit.

1485 For this type of protection, the requirements of IEC 60364–4–41 apply.

1486 **6.3.3 Protection by automatic disconnection of supply**

1487 Automatic disconnection of the supply of any circuit affected by an insulation fault is intended
1488 to prevent a hazardous situation resulting from a touch voltage.

1489 This measure consists of the interruption of one or more of the line conductors by the automatic
1490 operation of a protective device in case of a fault. This interruption shall occur within a
1491 sufficiently short time to limit the duration of a touch voltage to a time within the limits specified
1492 in [Annex A](#) for TN and TT systems.

1493 This measure necessitates co-ordination between:

- 1494 the type of supply system, the supply source impedance and the earthing system;
- 1495 the impedance values of the different elements of the line and of the associated fault current
1496 paths through the protective bonding circuit;
- 1497 the characteristics of the protective devices that detect insulation fault(s).

1498 Details of verification of conditions for protection by automatic disconnection of supply are
1499 provided in [18.2](#).

1500 This protective measure comprises both:

- 1501 protective bonding of exposed conductive parts (see [8.2.3](#)),
- 1502 and one of the following:

1503 Where automatic disconnection is provided in accordance with a), and disconnection within the
1504 time specified in [A.1.1](#) cannot be assured, supplementary protective bonding shall be provided
1505 as necessary to meet the requirements of [A.1.3](#).

1506 **6.4 Protection by the use of PELV**

1507 **6.4.1 General requirements**

1508 The use of [PELV](#) (Protective Extra-Low Voltage) is to protect persons against electric shock
1509 from indirect contact ([fault protection \(3.1.32\)](#)) and limited area direct contact [basic protection](#)
1510 ([3.1.5](#)) (see ??).

1511 [PELV](#) circuits shall satisfy all of the following conditions:

- 1512 the nominal voltage shall not exceed:
- 1513 "Ripple-free" is conventionally defined for a sinusoidal ripple voltage as a ripple content of
1514 not more than 10 % r.m.s.
- 1515 one side of the circuit or one point of the source of the supply of that circuit shall be
1516 connected to the protective bonding circuit;

live parts of **PELV** circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer (see IEC 61558–1 and IEC 61558–2–6);

conductors of each **PELV** circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of **13.1.3** shall apply;

plugs and socket-outlets for a **PELV** circuit shall conform to the following:

6.4.2 Sources for **PELV**

The source for **PELV** shall be one of the following:

a safety isolating transformer in accordance with IEC 61558–1 and IEC 61558–2–6;

a source of current providing a degree of safety equivalent to that of the safety isolating transformer (for example a motor generator with winding providing equivalent isolation);

an electrochemical source (for example a battery) or another source independent of a higher voltage circuit (for example a diesel-driven generator);

Certain electronic devices (e.g. switched mode power supply) complying with appropriate standards where provisions have been taken in order to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in **6.4.1**. Higher voltages at the outgoing terminals are, however, permitted if it is ensured that in the event of a fault, the voltage at the output terminals is immediately reduced to those values or less..

Examples of appropriate standards include IEC 61558-2-16, IEC 60950-1, IEC 61010-2-201

Sources for **PELV** can include power sources with **SELV** outputs where one side of the output is connected to the protective bonding circuit.

7 Protection of equipment

7.1 General

This **Clause 7** details the measures to be taken to protect equipment against the effects of:

overcurrent arising from a short-circuit;

overload and/or loss of cooling of motors;

abnormal temperature;

loss of or reduction in the supply voltage;

overspeed of machines/machine elements;

earth fault/residual current;

incorrect phase sequence;

overvoltage due to lightning and switching surges.

7.2 Overcurrent protection

7.2.1 General

An overcurrent in a circuit can be due to an overload and/or a short-circuit.

Circuits shall be protected against overload and short-circuit where these currents can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value.

Overload protection and short-circuit protection can be provided by a single protective device or separate protective devices. The ratings or settings to be selected are detailed in **7.2.10**.

1558 7.2.2 Supply conductors

1559 Unless otherwise specified by the user, the supplier of the electrical equipment is not
1560 responsible for providing the supply conductors and the overcurrent protective device for the
1561 supply conductors to the electrical equipment.

1562 Requirements for supply conductors and overcurrent protective device for the supply
1563 conductors may be subject local legislation.

1564 7.2.3 Power circuits

1565 Devices for detection and interruption of overcurrent, selected in accordance with [7.2.10](#), shall
1566 be applied to each live conductor (including circuits supplying control circuit transformers or
1567 control circuit power supplies).

1568 The following conductors, as applicable, shall not be disconnected without disconnecting all
1569 associated live conductors:

- 1570 the neutral conductor of [AC](#) power circuits;
- 1571 the earthed conductor of [DC](#) power circuits;
- 1572 [DC](#) power conductors bonded to exposed conductive parts of mobile machines.

1573 Where the cross-sectional area of the neutral conductor is at least equal to or equivalent to that
1574 of the line conductors, it is not necessary to provide overcurrent detection for the neutral
1575 conductor nor a disconnecting device for that conductor. For a neutral conductor with a cross-
1576 sectional area smaller than that of the associated line conductors, the measures detailed in 524
1577 of IEC 60364-5-52:2009 shall apply.

1578 In IT systems, it is recommended that the neutral conductor is not used. However, where a
1579 neutral conductor is used, the measures detailed in 431.2.2 of IEC 60364-4-43:2008 shall
1580 apply.

1581 7.2.4 Control circuits

1582 Conductors of control circuits directly connected to the supply voltage shall be protected against
1583 overcurrent in accordance with [7.2.3](#).

1584 Conductors of control circuits supplied by a transformer or power supply shall be protected
1585 against overcurrent (see also [9.4.3.1.1](#)):

- 1586 in control circuits connected to the protective bonding circuit, by inserting an overcurrent
1587 protective device into the switched conductor;
- 1588 in control circuits not connected to the protective bonding circuit;

1589 Exception: Where the supply unit provides current limiting below the current carrying capacity
1590 of the conductors in a circuit and below the current rating of connected components, no separate
1591 overcurrent protective device is required.

1592 7.2.5 Socket outlets and their associated conductors

1593 Overcurrent protection shall be provided for the circuits feeding the general purpose socket
1594 outlets intended primarily for supplying power to maintenance equipment. Overcurrent
1595 protective devices shall be provided in the unearthed live conductors of each circuit feeding
1596 such socket outlets. See also [15.1](#).

1597 7.2.6 Lighting circuits

1598 All unearthed live conductors of circuits supplying lighting shall be protected against the effects
1599 of short-circuits by the provision of overcurrent devices separate from those protecting other
1600 circuits.

1601 7.2.7 Transformers

1602 Transformers shall be protected by an overcurrent protective device having a type and setting
1603 in accordance with the transformer manufacturer's instructions. Such protection shall (see also
1604 [7.2.10](#)):

1605 avoid nuisance tripping due to transformer magnetizing inrush currents;

1606 avoid a winding temperature rise in excess of the permitted value for the insulation class of
1607 transformer when it is subjected to the effects of a short-circuit at its secondary terminals.

1608 7.2.8 Location of overcurrent protective devices

1609 For overload protection, the protective device can be located at any point within the circuit
1610 intended to be protected.

1611 For short-circuit protection, the protective device shall be located at or upstream of the point
1612 where a reduction in the cross-sectional area of the conductors or another change reduces the
1613 capability to withstand the short-circuit current to less than the required protection, except
1614 where all the following conditions are satisfied:

1615 the current carrying capacity of the conductors is at least equal to that of the load;

1616 the part of the conductor(s) between the point of reduction of short-circuit capacity and the
1617 position of the short-circuit protective device is no longer than 3 m;

1618 the conductors are installed in such a manner as to reduce the possibility of a short-circuit,
1619 for example, protected by an enclosure or duct.

1620 7.2.9 Overcurrent protective devices

1621 The rated short-circuit breaking capacity (for example, I_{cu} per IEC 60947-2 clause 4.3.5.2.1)
1622 shall be at least equal to the prospective fault current at the point of installation. Where the
1623 short-circuit current to an overcurrent protective device can include additional currents other
1624 than from the supply (for example from motors, from power factor correction capacitors), those
1625 currents shall be taken into consideration.

1626 Information on co-ordination under short-circuit conditions between a circuit-breaker and
1627 another short-circuit protective device is provided in Annex A of IEC 60947-2:2006,
1628 IEC 60947-2:2006/AMD1:2009 and IEC 60947-2:2006/AMD2:2013.

1629 Where fuses are provided as overcurrent protective devices, the type and ratings required shall
1630 be specified in the instructions for use (see 17.2). Selection of fuses should consider the
1631 availability in the country of use or arrangements should be made for the supply of spare parts.

1632 7.2.10 Rating and setting of overcurrent protective devices

1633 The rated current of fuses or the setting current of other overcurrent protective devices shall be
1634 selected as low as possible but adequate for the anticipated overcurrents (for example during
1635 starting of motors or energizing of transformers). When selecting those protective devices,
1636 consideration shall be given to the protection of switching devices against damage due to
1637 overcurrents.

1638 The rated current or setting of an overcurrent protective device for conductors is determined by
1639 the current carrying capacity of the conductors to be protected in accordance with [12.4](#), (see