

PRE-RELEASE VERSION (FDIS)



Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.200; 29.130.99; 13.110

Warning! Make sure that you obtained this publication from an authorized distributor.



22G/455/FDIS

FINAL DRAFT INTERNATIONAL STANDARD (FDIS)

PROJECT NUMBER:

IEC 61800-5-1 ED3

DATE OF CIRCULATION:

2022-05-20

CLOSING DATE FOR VOTING:

2022-07-01

SUPERSEDES DOCUMENTS:

22G/429/CDV, 22G/437A/RVC

IEC SC 22G : ADJUSTABLE SPEED ELECTRIC POWER DRIVE SYSTEMS (PDS)	
SECRETARIAT: United States of America	SECRETARY: Mr Christopher Johnson
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 2,TC 22,TC 44,SC 121A,SC 121B	HORIZONTAL STANDARD: <input type="checkbox"/>
FUNCTIONS CONCERNED: <input type="checkbox"/> EMC <input type="checkbox"/> ENVIRONMENT <input type="checkbox"/> QUALITY ASSURANCE <input checked="" type="checkbox"/> SAFETY	
<input checked="" type="checkbox"/> SUBMITTED FOR CENELEC PARALLEL VOTING Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Final Draft International Standard (FDIS) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	<input type="checkbox"/> NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is a draft distributed for approval. It may not be referred to as an International Standard until published as such.

In addition to their evaluation as being acceptable for industrial, technological, commercial and user purposes, Final Draft International Standards may on occasion have to be considered in the light of their potential to become standards to which reference may be made in national regulations.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy

PROPOSED STABILITY DATE: 2024

NOTE FROM TC/SC OFFICERS:

CONTENTS

FOREWORD.....	15
INTRODUCTION.....	17
0.1 General.....	17
0.2 Feedback from industry and national committees.....	19
0.3 Requirement covered by other relevant parts of the IEC 61800 series.....	19
1 Scope.....	20
2 Normative references.....	20
3 Terms and definitions.....	24
4 Protection against hazards.....	40
4.1 General.....	40
4.2 <i>Single-fault conditions</i> and <i>abnormal operating conditions</i>	41
4.3 Short-circuit and overload protection.....	42
4.3.1 General.....	42
4.3.2 Input short-circuit rating and available <i>output short-circuit current</i>	43
4.3.3 Short-circuit coordination (upstream protection).....	44
4.3.4 Protection by several devices.....	44
4.3.5 Motor overload and overtemperature protection.....	45
4.3.6 <i>BDM/CDM</i> providing current limiting control.....	46
4.4 Protection against electric shock.....	46
4.4.1 General.....	46
4.4.2 <i>Decisive voltage class (DVC)</i>	46
4.4.3 Provision for <i>basic protection</i>	53
4.4.4 Provision for <i>fault protection</i>	56
4.4.5 Provisions for <i>enhanced protection</i>	64
4.4.6 Protective measures.....	65
4.4.7 <i>Insulation</i>	67
4.4.8 Compatibility with residual current-operated protective devices (RCD).....	88
4.4.9 Capacitor discharge.....	89
4.4.10 Access conditions for high-voltage sections of <i>BDM/CDM/PDS</i> (<i>interlock</i>).....	89
4.5 Protection against electrical energy hazards.....	91
4.5.1 General.....	91
4.5.2 Determination of hazardous electrical energy level.....	92
4.5.3 Limited power sources.....	92
4.6 Protection against fire and thermal hazards.....	94
4.6.1 General.....	94
4.6.2 Circuits and <i>components</i> representing a fire hazard.....	94
4.6.3 Selection of <i>components</i> to mitigate the risk of a fire hazard.....	94
4.6.4 Fire protection provided by <i>enclosures</i>	95
4.6.5 Temperature limits.....	96
4.7 Protection against mechanical hazards.....	98
4.7.1 General.....	98
4.7.2 Critical torsional speed.....	99
4.7.3 Transient torque analysis.....	99
4.7.4 Specific requirements for liquid cooled <i>BDM/CDM/PDS</i>	99
4.7.5 Mechanical hazards from rotating parts.....	101

4.7.6	Sharp edges	102
4.8	<i>BDM/CDM/PDS</i> with multiple sources of supply	102
4.8.1	General	102
4.8.2	<i>Low-voltage</i> DC link sharing	103
4.9	Protection against environmental stresses	103
4.9.1	General	103
4.9.2	Protection against corrosion	105
4.10	Protection against excessive acoustic noise hazards	105
4.10.1	General	105
4.10.2	Acoustic noise level	105
4.11	Wiring and connections	106
4.11.1	General	106
4.11.2	<i>Insulation</i> of conductors	107
4.11.3	Stranded wire	109
4.11.4	Routing and clamping	109
4.11.5	Identification of conductors and terminals of <i>mains supply</i> and <i>non-mains supply</i>	109
4.11.6	Splices and connections	110
4.11.7	Accessible connections	110
4.11.8	Interconnections between parts of the <i>PDS</i>	111
4.11.9	Supply connections for <i>permanently connected BDM/CDM/PDS</i>	111
4.11.10	Supply connections for pluggable <i>BDM/CDM/PDS</i>	111
4.11.11	Terminals	113
4.11.12	Provisions for connecting the shield of shielded wire or cable	116
4.12	Mechanical requirements for <i>enclosures</i>	117
4.12.1	General	117
4.12.2	Handles and manual controls	117
4.12.3	Cast metal <i>enclosure</i>	118
4.12.4	Sheet metal <i>enclosure</i>	118
4.12.5	Stability for floor-standing <i>BDM/CDM/PDS</i>	121
4.12.6	Wiring strain relief	121
4.12.7	Polymeric <i>enclosure</i> stress relief	122
4.12.8	Internal condensation or accumulation of water	122
4.12.9	Polymeric outdoor <i>enclosure</i> ultra-violet (UV) resistance	122
4.13	<i>Components</i>	123
4.13.1	<i>Components</i> general	123
4.13.2	<i>Components</i> representing a fire hazard	123
4.13.3	<i>Components</i> being part of an <i>enclosure</i>	123
4.13.4	<i>Components</i> representing a mechanical hazard	124
4.13.5	Wound <i>components</i>	124
4.13.6	Protective devices	124
4.14	Protection against electromagnetic fields	124
5	Test requirements	124
5.1	General	124
5.1.1	Test objectives and classification	124
5.1.2	Selection of test samples	125
5.1.3	Sequence of tests	125
5.1.4	Earthing conditions	125
5.1.5	General conditions for tests	125

5.1.6	Compliance	126
5.1.7	Test overview	126
5.2	Test specifications	129
5.2.1	<i>Visual inspections (type test and routine test)</i>	129
5.2.2	Mechanical tests	129
5.2.3	Electrical tests	138
5.2.4	<i>Abnormal operation</i> and simulated faults tests	157
5.2.5	Material tests	170
5.2.6	Environmental tests (<i>type tests</i>)	174
5.2.7	Hydrostatic pressure test (<i>type test, routine test</i>)	180
5.2.8	Electromagnetic fields (EMF) test (<i>type test</i>)	181
6	Information and marking requirements	181
6.1	General	181
6.1.1	Overview	181
6.1.2	Documentation in electronic form	184
6.1.3	Installation Instructions	185
6.2	Information for selection	185
6.2.1	General	185
6.2.2	Instructions and markings pertaining to <i>accessories</i>	187
6.3	Information for installation and commissioning	187
6.3.1	General	187
6.3.2	Mechanical considerations	187
6.3.3	Environment	187
6.3.4	Handling and mounting	188
6.3.5	<i>Enclosure</i> temperature	188
6.3.6	Open type <i>BDM/CDM</i>	188
6.3.7	Connections	189
6.3.8	Commissioning	191
6.3.9	Protection requirements	191
6.3.10	Motor and driven equipment	195
6.3.11	Field installed <i>components</i>	196
6.4	Information for intended use	196
6.4.1	General	196
6.4.2	Adjustment	196
6.4.3	Labels, signs, symbols and signals	196
6.4.4	Hot surface	198
6.4.5	Control and device marking	198
6.4.6	Stability for floor-standing <i>BDM/CDM/PDS</i>	199
6.5	Supplementary information	199
6.5.1	General	199
6.5.2	Capacitor discharge	199
6.5.3	Special operation mode – Auto restart/bypass connection	200
6.5.4	Other hazards	200
6.5.5	<i>BDM/CDM/PDS</i> with multiple sources of supply	200
6.5.6	PT/CT connection	200
6.5.7	Access conditions for <i>high-voltage BDM/CDM/PDS</i> during maintenance	200
Annex A	(normative) Additional information for protection against electric shock	202
A.1	General	202
A.2	Protection by means of <i>DVC As</i>	202

A.3	Protection by means of <i>protective impedance</i>	203
A.4	Protection by using limited voltages	204
A.5	Evaluation of the <i>working voltage</i> of circuits.....	204
A.5.1	General	204
A.5.2	Classification of the <i>working voltage</i>	205
A.5.3	AC <i>working voltage</i>	205
A.5.4	DC <i>working voltage</i>	206
A.5.5	Pulsating <i>working voltage</i>	207
A.6	The concept of protective measures according to 4.4.....	208
A.6.1	General	208
A.6.2	General concept of protection against electric shock	209
A.6.3	Examples of the use of elements of protective measures	210
Annex B (informative)	Considerations for the reduction of the pollution degree	215
B.1	General.....	215
B.2	Factors influencing the pollution degree	215
B.3	Reduction of influencing factors	215
Annex C (informative)	Symbols referred.....	216
C.1	Symbols used	216
C.2	Determination of contrast.....	218
Annex D (normative)	Evaluation of <i>clearance</i> and <i>creepage distances</i>	219
D.1	Measurement.....	219
D.2	Relationship of measurement to pollution degree	219
D.3	Examples.....	219
Annex E (normative)	Altitude correction for <i>clearances</i>	226
E.1	Correction factor for <i>clearances</i> at altitudes above 2 000 m	226
E.2	Test voltages for verifying <i>clearances</i> at different altitudes	226
Annex F (normative)	<i>Clearance</i> and <i>creepage distance</i> determination for frequencies greater than 30 kHz	228
F.1	General influence of the frequency on the withstand characteristics.....	228
F.2	<i>Clearance</i>	228
F.2.1	General	228
F.2.2	<i>Clearance</i> for inhomogenous fields	229
F.2.3	<i>Clearance</i> for approximately homogenous fields	230
F.3	<i>Creepage distance</i>	231
F.4	<i>Solid insulation</i>	232
F.4.1	General	232
F.4.2	Approximately uniform field distribution without air gaps or voids.....	232
F.4.3	Other cases	233
Annex G (informative)	Cross-sections of round conductors	234
Annex H (informative)	Guidelines for RCD compatibility.....	235
H.1	Selection of RCD type.....	235
H.2	Fault current waveforms.....	236
Annex I (informative)	Examples of overvoltage category reduction.....	240
I.1	General.....	240
I.2	<i>Protection to the surroundings</i> (see 4.4.7.2).....	240
I.2.1	Circuits connected directly to <i>mains supply</i> (see 4.4.7.2.3).....	240
I.2.2	Circuits connected to the <i>non-mains supply</i> (see 4.4.7.2.4)	243
I.2.3	<i>Insulation</i> between circuits (see 4.4.7.2.5).....	243

I.3	<i>Functional insulation</i> (see 4.4.7.3)	244
I.4	Further examples	244
Annex J (informative)	Burn thresholds for touchable surfaces	246
J.1	General.....	246
J.2	Burn thresholds	246
Annex K (informative)	Table of electrochemical potentials	249
Annex L (informative)	Measuring instrument for touch current measurements	250
L.1	Measuring test circuit.....	250
L.2	Requirements for measuring instruments	250
Annex M (normative)	Test probes for determining access	251
Annex N (informative)	Guidance regarding short-circuit current	254
Annex O (informative)	Guidance for determination of <i>clearance</i> and <i>creepage distance</i>	255
O.1	Guideline for determination of <i>clearance</i>	255
O.2	Guideline for determination of <i>creepage distance</i>	256
O.3	Minimum <i>clearance</i> and <i>creepage distances</i> for material	257
Annex P (normative)	Protection of persons against electromagnetic fields for frequencies from 0 Hz up to 300 GHz	258
P.1	General influence of electromagnetic fields to persons.....	258
P.1.1	General	258
P.1.2	Low-frequency electric field effects (1 Hz to 100 kHz).....	258
P.1.3	Low-frequency magnetic field effects (1 Hz to 100 kHz).....	258
P.1.4	Low-frequency electric and magnetic field effects	258
P.1.5	High-frequency electromagnetic field effects (100 kHz to 300 GHz).....	258
P.1.6	Current knowledge on low-level effects.....	259
P.1.7	Biological effects versus adverse health effects	259
P.1.8	Influence of EMF on passive and active medical implants.....	259
P.2	Recommendations from ICNIRP Guidelines against exposure to EMF.....	259
P.2.1	Adoption of exposure limits from ICNIRP	259
P.2.2	Limits of EMF exposure for transportation and storage	261
P.3	Protection of persons against exposure of EMF	261
P.3.1	General	261
P.3.2	EMF requirements for general public access areas.....	262
P.3.3	EMF requirements for <i>general-access areas</i> , <i>service-access areas</i> and <i>restricted-access areas</i>	262
P.3.4	EMF requirements for transportation and storage	262
P.4	Electromagnetic fields (EMF) test (<i>type test</i>).....	263
P.4.1	General test set up for EMF	263
P.4.2	EMF test.....	263
P.5	Electromagnetic fields (EMF) marking	263
Annex Q (informative)	Automatic disconnection of supply	264
Q.1	Maximum disconnection times	264
Q.2	Supplementary <i>protective equipotential bonding</i>	265
Annex R (informative)	Risk assessment according to IEC Guide 116	266
R.1	General.....	266
R.2	Risk assessment.....	266
Annex S (informative)	In-some-country requirements – United States of America voltages less than 1,5 kV AC or DC	268
S.0	General.....	268

S.1	Scope	268
S.2	Normative references.....	268
S.3	Terms and definitions.....	268
S.4	Protection against hazards.....	269
S.4.1	General	269
S.4.2	<i>Single-fault conditions and abnormal operating condition</i>	269
S.4.3	Short-circuit and overload protection	269
S.4.4	Protection against electric shock	271
S.4.5	Protection against electrical energy hazards.....	281
S.4.6	Protection against fire and thermal hazards.....	281
S.4.7	Protection against mechanical hazards.....	282
S.4.8	<i>BDM/CDM/PDS</i> with multiple sources of supply	284
S.4.9	Protection against environmental stresses.....	284
S.4.10	Protection against excessive acoustic noise hazards	284
S.4.11	Wiring and connections	284
S.4.12	Mechanical requirements for <i>enclosures</i>	294
S.4.200	Auxiliary device	306
S.4.201	<i>Accessories</i>	306
S.4.202	Provisions for mounting	306
S.4.203	Capacitors	306
S.5	Test requirements.....	307
S.5.1	General	307
S.5.2	Test specifications.....	308
S.6	Information and marking requirements	328
S.6.1	General	328
S.6.2	Information for selection	328
S.6.3	Information for installation and commissioning.....	329
S.6.4	Information for intended use	333
S.6.5	Supplementary information	333
S.200	Evaluation of clearance and <i>creepage distances</i>	334
S.200.1	<i>Clearance and creepage distances</i>	335
S.201	Normative references and component standards.....	337
S.202	IEC to USA standard references	340
S.203	Isolated secondary circuits and circuits supplied by battery	343
S.203.1	Isolated secondary circuits	343
S.203.2	Secondary circuits test	349
S.203.3	Circuits supplied by a battery.....	351
S.204	Full-load motor-running currents	351
Annex T (informative)	In-some-country requirements – Canada voltages up to 34,5 kV.....	354
T.0	General.....	354
T.1	Scope	354
T.2	Normative references.....	354
T.3	Terms and definitions.....	356
T.4	Protection against hazards.....	357
T.4.1	General	357
T.4.2	<i>Single-fault conditions and abnormal operating condition</i>	357
T.4.3	Short-circuit and overload protection	357
T.4.4	Protection against electric shock	358
T.4.5	Protection against electrical energy hazards.....	367

T.4.6	Protection against fire and thermal hazards	368
T.4.7	Protection against mechanical hazards	369
T.4.8	<i>BDM/CDM/PDS</i> with multiple sources of supply	369
T.4.9	Protection against environmental stresses	369
T.4.10	Protection against excessive acoustic noise hazards	369
T.4.11	Wiring and connections	369
T.4.12	Mechanical requirements for <i>enclosures</i>	381
T.4.13	<i>Components</i>	386
T.4.14	Protection against electromagnetic fields	391
T.5	Test requirements	391
T.5.1	General	391
T.5.2	Test specifications	391
T.6	Information and marking requirements	416
T.6.1	General	416
T.6.2	Information for selection	418
T.6.3	Information for installation and commissioning	419
T.6.4	Information for intended use	421
T.6.5	Supplementary information	423
	Bibliography	426
	Figure 1 – <i>PDS</i> hardware configuration within an <i>installation</i>	35
	Figure 2 – Time-voltage zones for <i>DVC A</i> s and <i>DVC B</i> circuits – DC	50
	Figure 3 – Time-voltage zones for <i>DVC A</i> s and <i>DVC B</i> circuits – AC peak	51
	Figure 4 – Time-voltage zones for conductive <i>accessible parts</i>	52
	Figure 5 – Example of a <i>protective class I BDM/CDM</i> arrangement and its associated <i>protective equipotential bonding</i>	58
	Figure 6 – Example of a <i>protective class I BDM/CDM</i> arrangement and its associated <i>protective equipotential bonding</i> through direct metallic contact	59
	Figure 7 – Example for interconnections within <i>BDM/CDM</i> and between parts of the <i>PDS106</i>	
	Figure 8 – Example for interconnections between parts of the <i>PDS</i> (<i>BDM/CDM</i> parts separated by field wiring)	107
	Figure 9 – Example arrangement of insulated conductors in a cable	108
	Figure 10 – Detachable <i>mains supply</i> cords and connections	112
	Figure 11 – Wire bending space	116
	Figure 12 – Supported and unsupported <i>enclosure</i> parts	119
	Figure 13 – Impact test using a steel ball	135
	Figure 14 – Voltage test procedures	146
	Figure 15 – Partial discharge test procedure	148
	Figure 16 – Electric strength test instrument	154
	Figure 17 – Mandrel	155
	Figure 18 – Initial position of mandrel	155
	Figure 19 – Final position of mandrel	155
	Figure 20 – Position of metal foil on insulating material	156
	Figure 21 – <i>Protective equipotential bonding</i> test set up	160
	Figure 22 – Example of short-circuit test between <i>BDM/CDM</i> motor power port and <i>protective earth</i> (motor separately earthed)	162

Figure 23 – Example of short-circuit test between <i>BDM/CDM</i> motor power <i>port</i> and <i>protective earth</i> (motor earthed through <i>BDM/CDM</i>).....	162
Figure 24 – Example of short-circuit test between <i>BDM/CDM</i> DC link power <i>port</i> and <i>protective earth</i>	163
Figure 25 – Interpolated values for Table 37	165
Figure 26 – Circuit for high-current arcing test	171
Figure 27 – Test fixture for hot-wire ignition test	172
Figure A.1 – Protection by <i>DVC As</i> with <i>enhanced protection</i>	202
Figure A.2 – Protection by means of <i>protective impedance</i>	203
Figure A.3 – Protection by using limited voltages	204
Figure A.4 – Typical waveform for AC <i>working voltage</i>	205
Figure A.5 – Typical waveform for DC <i>working voltage</i>	206
Figure A.6 – Typical waveform for pulsating <i>working voltage</i>	207
Figure A.7 – Protective measures according to 4.4.1 to 4.4.5 for protection against electric shock considering <i>protective class I</i> and <i>protective class II BDM/CDM/PDS</i>	209
Figure A.8 – Protective measures according to 4.4.1 to 4.4.5 for protection against electric shock considering <i>protective class III BDM/CDM/PDS</i> and <i>DVC As</i> circuits	210
Figure D.1 – Example of measurements including a groove	220
Figure D.2 – Example of measurements including a groove	220
Figure D.3 – Example of measurements including a groove	220
Figure D.4 – Example of measurements including a rib.....	220
Figure D.5 – Example of measurements providing protection of type 2.....	221
Figure D.6 – Example of measurements providing protection of type 1.....	221
Figure D.7 – Example of measurements providing protection of type 1.....	221
Figure D.8 – Example of measurements providing protection of type 1.....	222
Figure D.9 – Example of measurements including a barrier (cemented joint).....	222
Figure D.10 – Example of measurements including a barrier.....	222
Figure D.11 – Example of measurements including a gap	223
Figure D.12 – Example of measurements including a gap	223
Figure D.13 – Example of measurements including an floating conductive part.....	224
Figure D.14 – Example of measurements in inner layer of PWB.....	224
Figure D.15 – Example of measurements in an <i>enclosure</i> of insulating material.....	225
Figure F.1 – Diagram for dimensioning of <i>clearances</i> above 30 kHz	229
Figure F.2 – Diagram for dimensioning of <i>creepage distances</i> above 30 kHz	231
Figure F.3 – Permissible field strength for dimensioning of <i>solid insulation</i> according to Formula (F.1).....	233
Figure H.1 – Flow chart leading to selection of the RCD type upstream of a <i>PDS</i>	235
Figure H.2 – Symbols for marking depending on the type of RCD	236
Figure H.3 – Fault current waveforms in connections with <i>BDM/CDM/PDS</i>	239
Figure I.1 – <i>Basic protection</i> evaluation for circuits connected to the origin of the <i>installation mains supply</i>	240
Figure I.2 – <i>Basic protection</i> evaluation for circuits connected to the <i>mains supply</i>	241
Figure I.3 – <i>Basic protection</i> evaluation for single and three phase <i>BDM/CDM/PDS</i> not <i>permanently connected</i> to the <i>mains supply</i>	241
Figure I.4 – <i>Basic protection</i> evaluation for circuits connected to the origin of the <i>installation mains supply</i> where internal SPDs are used.....	241

Figure I.5 – <i>Basic protection</i> evaluation for circuits connected to the <i>mains supply</i> where internal SPDs are used.....	242
Figure I.6 – Example of <i>enhanced protection</i> evaluation for circuits connected to the <i>mains supply</i> where internal SPDs are used	242
Figure I.7 – Example of <i>enhanced protection</i> evaluation for circuits connected to the <i>mains supply</i> where internal SPDs are used	242
Figure I.8 – Example of <i>enhanced protection</i> evaluation for circuits connected to the <i>mains supply</i> where internal SPDs are used	243
Figure I.9 – <i>Basic protection</i> evaluation for circuits connected to the <i>non-mains supply</i>	243
Figure I.10 – <i>Basic protection</i> evaluation for circuits connected to the origin of the <i>installation non-mains supply</i>	243
Figure I.11 – <i>Functional insulation</i> evaluation within circuits affected by external transients.....	244
Figure I.12 – <i>Basic protection</i> evaluation for circuits connected to the <i>mains supply</i> and a non-mains circuit	244
Figure I.13 – <i>Insulation</i> evaluation for <i>accessible circuit</i> of <i>DVC As</i>	245
Figure J.1 – Burn threshold spread when the skin is in contact with a hot smooth surface made of bare (uncoated) metal.....	246
Figure J.2 – Rise in the burn threshold spread from Figure J.1 for metals which are coated by shellac varnish of a thickness of 50 µm, 100 µm and 150 µm.....	247
Figure J.3 – Rise in the burn threshold spread from Figure J.1 for metals coated with the specific materials	247
Figure J.4 – Burn threshold spread when the skin is in contact with a hot smooth surface made of ceramics, glass and stone materials	248
Figure J.5 – Burn threshold spread when the skin is in contact with a hot smooth surface made of plastics	248
Figure L.1 – Measuring test circuit	250
Figure M.1 – Sphere 50 mm probe according to IEC 61032:1997, test probe A.....	251
Figure M.2 – Jointed test finger according to IEC 61032:1997, test probe B.....	252
Figure M.3 – Test rod 2,5 mm according to IEC 61032:1997, test probe C	253
Figure M.4 – Sphere 12,5 mm test probe according to IEC 61032:1997, test probe 2.....	253
Figure O.1 – Flowchart <i>clearance</i>	255
Figure O.2 – Flowchart <i>creepage distance</i>	256
Figure S.1 – Articulate probe with web stop	298
Figure S.2 – Determination of current for circuits of 10 000 A and less	318
Figure S.3 – Peak let-through current	322
Figure S.4 – Application of Simpson's rule to fuse current oscillogram to obtain let-through I^2t	323
Figure S.5 – Clamped joint.....	334
Figure T.1 – Routing conductors through a metal barrier.....	376
Figure T.2 – Wire bending space	380
Figure T.3 – Test circuit using Formula BB.1	400
Figure T.4 – Test circuit using Formula BB.2	401
Figure T.5 – Test circuit using Formula BB.3	401
Figure T.6 – Test circuit using Formula BB.4	402
Figure T.7 – Typical test set sensitivity	403
Figure T.8 – Determination of current and power factor for circuits of 10 000 A and less.....	412

Table 1 – Alphabetical list of terms	25
Table 2 – Voltage limits for the <i>decisive voltage classes</i>	49
Table 3 – Protection requirements for circuits under consideration	53
Table 4 – <i>PE conductor</i> cross-section	60
Table 5 – Definitions of pollution degrees	68
Table 6 – <i>Impulse withstand voltage</i> and <i>temporary overvoltage</i> versus <i>system voltage</i> for <i>low-voltage</i> circuits	71
Table 7 – <i>Impulse withstand voltage</i> and <i>temporary overvoltage</i> versus <i>system voltage</i> for high-voltage circuits	71
Table 8 – <i>Clearance</i> for <i>functional insulation</i> , <i>basic insulation</i> or <i>supplementary insulation</i>	76
Table 9 – Insulating materials classification	79
Table 10 – <i>Creepage distances</i>	80
Table 11 – <i>Insulation</i> material requirements	83
Table 12 – Distance to uninsulated <i>live parts</i> for consideration of HWI, HAI and CTI	83
Table 13 – Generic materials for <i>insulation</i> material	84
Table 14 – Requirements based on thin sheet material thickness	85
Table 15 – Limits for power sources without an <i>overcurrent</i> protective device	93
Table 16 – Limits for power sources with an <i>overcurrent</i> protective device	93
Table 17 – Maximum measured temperatures for internal materials and <i>components</i>	96
Table 18 – Maximum measured temperatures for <i>accessible parts</i> of <i>BDM/CDM/PDS</i>	98
Table 19 – Minimum tubing wall thickness	100
Table 20 – Environmental service conditions	104
Table 21 – Wire bending space from terminals to <i>enclosure</i>	115
Table 22 – Thickness of sheet metal for <i>enclosures</i> : carbon steel or stainless steel	120
Table 23 – Thickness of sheet metal for <i>enclosures</i> : aluminium, copper or brass	121
Table 24 – Environmental conditions for tests	126
Table 25 – Test overview	127
Table 26 – Pull values for handles and manual control securement	136
Table 27 – Values for physical tests on strain relief of <i>enclosure</i>	137
Table 28 – <i>Impulse withstand voltage</i> test	139
Table 29 – <i>Impulse withstand voltage</i> test voltage for <i>low-voltage BDM/CDM/PDS</i>	140
Table 30 – <i>Impulse withstand voltage</i> test voltage for <i>high-voltage BDM/CDM/PDS</i>	141
Table 31 – AC or DC test voltage for circuits connected directly to <i>low-voltage mains supply</i>	142
Table 32 – AC or DC test voltage for circuits connected directly to <i>high-voltage mains supply</i>	143
Table 33 – AC or DC test voltage for circuits connected to <i>non-mains supply</i> without <i>temporary overvoltages</i>	144
Table 34 – Parameter for <i>BDM/CDM/PDS</i> AC or DC voltage test	147
Table 35 – Partial discharge test	148
Table 36 – <i>Prospective short-circuit current</i> for test vs <i>BDM/CDM</i> rated input current	158
Table 37 – Maximum tripping time for <i>electronic motor overload protection</i> test	164
Table 38 – Environmental tests	175

Table 39 – Preconditioning or recovery procedure for climatic tests (<i>type test</i>)	176
Table 40 – Dry heat test (steady state) (<i>type test</i>).....	176
Table 41 – Cold test (<i>type test</i>).....	177
Table 42 – Damp heat test (steady state) (<i>type test</i>).....	177
Table 43 – Damp heat test (cyclic) (<i>type test</i>).....	178
Table 44 – Vibration test.....	179
Table 45 – Salt mist test.....	179
Table 46 – Dust test.....	180
Table 47 – Sand test.....	180
Table 48 – Marking location.....	182
Table A.1 – Configurations for protection against electric shock.....	212
Table C.1 – Symbols used.....	216
Table D.1 – Width of grooves by pollution degree.....	219
Table E.1 – Correction factor for <i>clearances</i> at altitudes between 2 000 m and 20 000 m.....	226
Table E.2 – Test voltages for verifying <i>clearances</i> at different altitudes.....	227
Table F.1 – Minimum values of <i>clearances</i> in air at atmospheric pressure for inhomogeneous field conditions.....	230
Table F.2 – Multiplication factors for <i>clearances</i> in air at atmospheric pressure for approximately homogeneous field conditions.....	230
Table F.3 – Minimum values of <i>creepage distances</i> for different frequency ranges.....	232
Table G.1 – Standard cross-sections of round conductors.....	234
Table K.1 – Table of electrochemical potentials.....	249
Table O.1 – Minimum <i>clearance</i> and <i>creepage distances</i> for material.....	257
Table P.1 – Limits of EMF for general public exposure.....	260
Table P.2 – Limits of EMF for occupational exposure.....	261
Table P.3 – Limits for magnetic flux density of static magnetic fields.....	261
Table P.4 – EMF test overview.....	263
Table 41.1 – Maximum disconnection times.....	264
Table R.1 – Risk assessment.....	266
Table S.1 – Size of bonding conductor.....	273
Table S.2 – Duration of current flow for bonding-conductor test.....	273
Table S.3 – Bonding conductor short-circuit test capacity.....	273
Table S.4 – Maximum rating of <i>overcurrent</i> device.....	275
Table S.5 – Dimensions of bushings.....	277
Table S.6 – <i>BDM/CDM/PDS</i> intended for installation in a feeder circuit.....	277
Table S.7 – <i>Generic materials for barriers</i>	279
Table S.8 – Tubing wall thickness.....	283
Table S.9 – Ampacity of flexible cord.....	286
Table S.10 – Ampacities of insulated conductors.....	289
Table S.11 – Wire bending space at the terminals of enclosed power conversion equipment.....	291
Table S.12 – <i>Overcurrent</i> protective device.....	292
Table S.13 – Branch-circuit short-circuit protective device.....	293

Table S.14 – Openings in <i>enclosures</i>	299
Table S.15 – Addition to Table 3 of UL 50:2015: Thickness of sheet metal for <i>enclosures</i> – Carbon steel or stainless steel	301
Table S.16 – Addition to Table 4 of UL 50:2015: Thickness of sheet metal for <i>enclosures</i> – Aluminum, copper or brass.....	301
Table S.17 – Dimensions of knockout	304
Table S.18 – Values of voltage for tests.....	307
Table S.19 – AC or DC voltage test voltages	310
Table S.20 – Width of copper bus bars	311
Table S.21 – Production-line test conditions	312
Table S.22 – Power factor of test circuits for devices rated 600 V or less.....	326
Table S.23 – Minimum <i>clearances</i> and <i>creepage distances</i> at <i>field wiring terminals</i> up to 600 V.....	335
Table S.24 – Minimum <i>clearances</i> and <i>creepage distances</i> for <i>field wiring terminals</i> over 600 V.....	336
Table S.25 – <i>Clearances</i> and <i>creepage distances</i> at <i>field wiring terminals</i> for pollution degree 2 environments	337
Table S.26 – IEC normative reference standards that do not apply	341
Table S.27 – IEC normative references replaced by USA standards	342
Table S.28 – Secondary circuits, differences in evaluation.....	344
Table S.29 – Full-load motor-running currents in amperes corresponding to various AC horsepower ratings	352
Table S.30 – Full-load motor-running currents in amperes corresponding to various DC horsepower ratings	353
Table T.1 – Size and number of bonding conductors per termination	359
Table T.2 – Size of bonding conductor	359
Table T.3 – Minimum <i>clearance</i> and <i>creepage distances</i> on <i>field wiring terminals</i>	361
Table T.4 – Dimensions of bushings	362
Table T.5 – Test voltages for verifying <i>clearances</i>	365
Table T.6 – Test voltages for verifying <i>clearances</i> using AC RMS.....	365
Table T.7 – Generic material acceptable as a barrier	366
Table T.8 – Allowable ampacities of insulated copper conductors inside industrial control equipment <i>enclosures</i> (based on a <i>ambient temperature</i> of 40 °C).....	370
Table T.9 – Ampacity correction factors for multiple conductor groupings	370
Table T.10 – Wiring space	371
Table T.11 – Wire-bending space	372
Table T.12 – Full-load motor-running currents in amperes corresponding to AC horsepower ratings	373
Table T.13 – Full-load motor-running currents in amperes corresponding to DC horsepower ratings	374
Table T.14 – Wire-bending space	376
Table T.15 – Test values for <i>BDM/CDM/PDS</i> wiring terminals.....	378
Table T.16 – Ampacity of conductors based on resistor duty cycle ratings	379
Table T.17 – Thickness of sheet metal for <i>enclosures</i> – Carbon steel or stainless steel.....	383
Table T.18 – Thickness of sheet metal for <i>enclosures</i> – Aluminum, copper, or brass	384
Table T.19 – Maximum acceptable rating of primary <i>overcurrent</i> device.....	388

Table T.20 – Minimum acceptable rating of secondary <i>overcurrent</i> device	388
Table T.21 – <i>Overcurrent</i> protective device – Copper conductors	389
Table T.22 – <i>High-Voltage BDM/CDM/PDS</i> dielectric strength test values, kV.....	390
Table T.23 – Tightening torque for testing conduit hubs of polymeric <i>enclosures</i>	393
Table T.24 – Bending moment	394
Table T.25 – Test circuit sensitivity formulas.....	400
Table T.26 – Ampacities of insulated conductors	405
Table T.27 – Size of copper busbar connections for temperature test	406
Table T.28 – Short-circuit test values.....	407
Table T.29 – Short-circuit power factor	411
Table T.30 – Translation of markings	416
Table T.31 – IEC normative references replaced by CSA standards.....	423

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 5-1: Safety requirements – Electrical, thermal and energy

FOREWORD

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

IEC 61800-5-1 has been prepared by subcommittee 22G: Adjustable speed electric power drive systems (PDS), of IEC technical committee 22: Power electronic systems and equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2007 and Amendment 1:2016. This edition constitutes a technical revision.

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

- a) harmonization with IEC 62477-1:2022;
- b) harmonization with UL 61800-5-1 and CSA C22.2 No. 274, including an annex with a list of national deviation which was considered not possible to harmonize within a reasonable timeframe;
- c) more detailed information about the evaluation of components according to this document and relevant safety component standards;
- d) updated requirement for mechanical hazards including multiple IP ratings.

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

Draft	Report on voting
22G/XX/FDIS	22G/XX/RVD

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

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

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

In this document, terms in *italic* are defined in Clause 3.

The reader's attention is drawn to the fact that

- Annex S and Annex T list all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.
- Due to the rules of ISO/IEC Directives, Part 2, the term "must" instead of the term "shall" is used in Annex S and Annex T.

A list of all parts of the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems*, is available on the IEC website.

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

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

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

INTRODUCTION

0.1 General

This document contains the revision of IEC 61800-5-1:2007 and IEC 61800-5-1:2007/AMD1:2016.

Several important issues have influenced the scope and the chosen approach of the maintenance of IEC 61800-5-1:2007 in the development of this document.

The most significant changes compared to IEC 61800-5-1:2007 are the following.

a) Structure and content is based on IEC 62477-1 considering modifications and new topics such as the following

- Clause 1: Scope updated to include radio emitting/transmitting *BDM/CDM/PDS*.
- 4.1, 5.1, 6.1: "Intended use" included.
- 4.2: Single fault/abnormal operation analysis (significantly reworked).
- 4.3: Short-circuit and overload protection included as new subclause.
- 4.4 and Annex A: Protection against electric shock updated according to IEC 61140:2016 and IEC 60364-4-41, including insulation coordination according to IEC 60664 (all parts) considering the following:
 - 4.4.2 – Decisive voltage classification (especially DVC As for dry, wet and salt-water wet); Table 2 and Table 3 reworked;
 - 4.4.3 – Basic protection (reworked);
 - 4.4.4 – Fault protection (reworked);
 - 4.4.5 – Enhanced protection (reworked);
 - 4.4.7 – Insulation (reworked):
 - 4.4.7.1.2 – Working voltage (new);
 - 4.4.7.1.8 – Components bridging insulation (new);
 - 4.4.7.7 – *clearance* and *creepage distances* for functional insulation on PWB and component assemblies (reworked);
 - 4.4.7.8 – Solid insulation (new/reworked);
 - 4.4.7.9 – Connection of parts of solid insulation (cemented joints) (new);
 - 4.4.8/Annex H – Compatibility with RCD (reworked);
 - 4.4.10 – Access conditions for *high-voltage PDS* (new).
- 4.5: Protection against energy hazards (new).
- 4.6: Protection against fire and thermal hazards (new).
- 4.7: Protection against mechanical hazards (new).
- 4.8: *BDM/CDM/PDS* with multiple sources of supply (new).
- 4.9: Protection against environmental stresses (new) (in alignment with IEC 61800-2).
- 4.11: Wiring and connections updated (significantly reworked).
- 4.12: Enclosure updated (significantly reworked).
- 4.13 Bibliography: Evaluation of components (new).
- 4.14 Annex P: Protection against electromagnetic fields (new).
- Clause 5: Updated with some additional/modified test requirement:
 - 5.2.2.2 – Non-accessibility test (significantly reworked);
 - 5.2.2.3 – Ingress protection test (IP rating) (significantly reworked);

- 5.2.2.4 – Enclosure integrity tests (new);
- 5.2.2.5 – Wall or ceiling mounted *BDM/CDM/PDS* test (new);
- 5.2.2.6 – Handles and manual control securement test (new);
- 5.2.2.7 – Strain relief test (new);
- 5.2.3.7 – Touch current measurement test (reworked);
- 5.2.3.9 – Limited power source (new);
- 5.2.3.11 – Protective equipotential bonding test (new);
- 5.2.3.12 – Input test (new);
- 5.2.3.13 – Thin sheet material test (new);
- 5.2.3.14 – Test procedure for determination of working voltage (new);
- 5.2.3.16 – Preconditioning of material (reworked);
- 5.2.4.4 – Protective equipotential bonding short-circuit test (new);
- 5.2.4.9 – Output overload test (new);
- 5.2.4.13.5 – Covering of openings for cooling air test (type test) (new);
- 5.2.5.6 – Cemented joints test (new);
- 5.2.7 – Hydrostatic pressure test (new);
- 5.2.8 – Electromagnetic fields (EMF) test (new).
- Clause 6: – Update with more specific marking.
 - Structure aligned with IEC 62477-1 as close as possible;
 - Table 48 simplified.
- Annex A – Additional information for protection against electric shock (reworked).
- Annex C – Symbols referred (reworked).
- Annex E – Altitude correction for *clearances* (reworked).
- Annex F – *Clearance* and *creepage distance* determination for frequencies greater than 30 kHz (reworked).
- Annex H – Guidelines for RCD compatibility (reworked).
- Annex M – Test probes for determining access (new).
- Annex O – Guidance for determination of *clearance* and *creepage distance* (new).
- Annex P – Protection of persons against electromagnetic fields for frequencies from 0 Hz up to 300 GHz (new).
- Annex Q – Automatic disconnection of supply (new).
- Annex R – Guide 116 risk evaluation included.
- Bibliography – Relevant component safety standards (new).

b) Harmonization with UL 61800-5-1

Complete document is modified taken into consideration UL 61800-5-1 US National deviations. US National deviations from UL 61800-5-1 not possible to harmonize have been placed in Annex S.

c) Harmonization with CSA C22.2 No. 274

- Due to a short time frame, only some few topics have been harmonized.
- Canadian National deviations from CSA C22.2 No. 274 not possible to harmonize have been placed in Annex T.

d) Harmonization with UL 347A

- Some few relevant topics have been harmonized considering safety aspects related to *high-voltage BDM/CDM/PDS*.

Further harmonization is expected to be adopted in IEC 61800-5-1 considering the content of UL 61800-5-1, CSA C22.2 No 274 and UL 347A in future editions of IEC 61800-5-1.

0.2 Feedback from industry and national committees

The use of IEC 61800-5-1:2007 by manufacturers and test institutes since its release has identified several topics which are considered useful to implement, or topics which need further information for a better understanding of the intent of the specific requirement. These topics are also implemented in this document.

0.3 Requirement covered by other relevant parts of the IEC 61800 series

- general requirements for DC *power drive systems* are covered in IEC 61800-1;
- general requirements for AC *power drive systems* are covered in IEC 61800-2;
- EMC aspects are covered in IEC 61800-3;
- functional safety aspects are covered in IEC 61800-5-2;
- functional safety aspects for encoders are covered in IEC 61800-5-3;
- type of load duty aspects are covered in IEC TR 61800-6;
- communication profiles aspects are covered in IEC 61800-7 (all parts);
- *power interface* voltage aspects are covered in IEC TS 61800-8;
- ecodesign aspects are covered in IEC 61800-9 (all parts);

The following document is not part of the IEC 61800 series, but is used often as part of the BDM:

- active infeed converters in IEC TS 62578.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 5-1: Safety requirements – Electrical, thermal and energy

1 Scope

This part of IEC 61800 specifies requirements for adjustable speed electrical *power drive systems (PDS)* or their elements, with respect to electrical, thermal, fire, mechanical, energy and other relevant hazards. It does not cover the driven equipment except for interface requirements. It applies to adjustable speed electrical *PDS* which include the power conversion, *basic drive module (BDM)/complete drive module (CDM)* control, and a motor or motors.

Excluded are traction and electric vehicle *BDM/CDM*.

It applies to low-voltage adjustable speed electrical *PDS* intended to feed a motor or motors from a *BDM/CDM* connected to phase-to-phase voltages of up to and including 1,0 kV AC (50 Hz or 60 Hz) and up to and including 1,5 kV DC.

It also applies to high-voltage adjustable speed electrical *PDS* intended to feed a motor or motors from a *BDM/CDM* connected to phase-to-phase voltages of up to and including 35 kV AC (50 Hz or 60 Hz) and up to and including 52 kV DC.

NOTE 1 At the time of publication of this document, the technical limit for DC motors is 2,25 kV DC.

NOTE 2 Above voltage and frequency limits reflect the scope of IEC 61800-1 and IEC 61800-2.

NOTE 3 For adjustable speed electrical *PDS* not covered by the scope of this document, applicable requirements of other standards, for example IEC 62477-1 and IEC 62477-2, can be used.

This document also applies to *PDS* which intentionally emits or receives radio waves for the purpose of radio communication.

Motors for driven equipment (see Figure 1) complies with IEC 60034 (all parts).

NOTE 4 In some cases, safety requirements of the *PDS* (for example, protection against access to hazardous parts) can necessitate the use of special components and/or additional measures.

2 Normative references

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

IEC 60034 (all parts), *Rotating electrical machines*

IEC 60034-1:2022, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5:2020, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60050-112, *International Electrotechnical Vocabulary (IEV) – Part 112: Quantities and units* (available at www.electropedia.org)

IEC 60050-113, *International Electrotechnical Vocabulary (IEV) – Part 113: Physics for electrotechnology* (available at www.electropedia.org)

IEC 60050-114, *International Electrotechnical Vocabulary (IEV) – Part 114: Electrochemistry* (available at www.electropedia.org)

IEC 60050-131, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory* (available at www.electropedia.org)

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at www.electropedia.org)

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility* (available at www.electropedia.org)

IEC 60050-192, *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability* (available at www.electropedia.org)

IEC 60050-426, *International Electrotechnical Vocabulary (IEV) – Part 426: Explosive atmospheres* (available at www.electropedia.org)

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at www.electropedia.org)

IEC 60050-442, *International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories* (available at www.electropedia.org)

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics* (available at www.electropedia.org)

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Part 601: Generation, transmission and distribution of electricity – General* (available at www.electropedia.org)

IEC 60050-826, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations* (available at www.electropedia.org)

IEC 60050-903, *International Electrotechnical Vocabulary (IEV) – Part 903: Risk assessment* (available at www.electropedia.org)

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-52:2017, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-68:1994, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60204-11:2018, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

IEC 60320 (all parts), *Appliance couplers for household and similar general purposes*

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

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*
IEC 60364-5-54:2011/AMD1:2021

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60617, *Graphical symbols for diagrams* (available at <http://std.iec.ch/iec60617>)

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:2016, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60695-2-10:2021, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2021, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-2-13:2021, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignition temperature (GWIT) test method for materials*

IEC 60695-10-2:2014, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60695-11-20:2015, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test method*

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weatherprotected locations*¹

IEC 60721-3-3:1994/AMD1:1995

IEC 60721-3-3:1994/AMD2:1996

IEC 60721-3-4:2019, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Stationary use at non-weatherprotected locations*

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*

IEC 60730-1:2013/AMD1:2015

IEC 60730-1:2013/AMD2:2020

IEC 60755:2017, *General safety requirements for residual current operated protective devices*

IEC 60799:2018, *Electrical accessories – Cord sets and interconnection cord sets*

IEC 60947-4-1:2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61084 (all parts), *Cable trunking systems and cable ducting systems for electrical installations*

IEC 61180:2016, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61189-3:2007, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

IEC 61230:2008, *Live working – Portable equipment for earthing or earthing and short-circuiting*

IEC 61386 (all parts), *Conduit systems for cable management*

IEC 61558-1:2017, *Safety of power transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 62109-1:2010, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

IEC 62271-102:2018, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62477-1:2022, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

¹ This publication has been withdrawn.

IEC 62477-2:2018, *Safety requirements for power electronic converter systems and equipment – Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC*

ISO 3864-1:2011, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 3746:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 7000, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs* (available at <https://www.iso.org/obp>)

ISO 9614-1:1993, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*